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THE LIFE HISTORY OF ASCOBOLUS MAGNIFICUS

ORIGIN OF THE ASCOCARP FROM TWO STRAINS

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(With Plates 7, 8, and Figures 1–28 in the Text)

During the years since *Ascobolus magnificus* was first described (6), I have been carrying on from time to time culture studies of this fungus with the hope of being able to settle several puzzling questions that have arisen with regard to it. Apparently it has been collected in Porto Rico several times and some of these specimens have been identified by Dr. F. J. Seaver and deposited in the herbarium of the New York Botanical Garden. The identification of the forms from Porto Rico could be checked up by the use of artificial cultures. It is certainly unknown in Europe or otherwise except from my cultures. In this preliminary paper I shall discuss briefly the following topics: (1) The development of the primordia—ascogonia and antheridia. (2) The asexual or *Papulospora* stage. (3) Intrahyphal mycelium. (4) The necessity of two strains in sexual reproduction.

Atkinson (1), in his usual vigorous style, arrayed the evidence against a theory of the origin of the Ascomycetes from the Florideae and endeavored to show how the Oömycetes, through *Dipodascus*, may have been the ancestors of our "higher" Ascomycetes. It was his opinion that the trichogyne could have arisen by the further development of the receptive papilla of the oögonium. He says that no one has ever proved that the multi-

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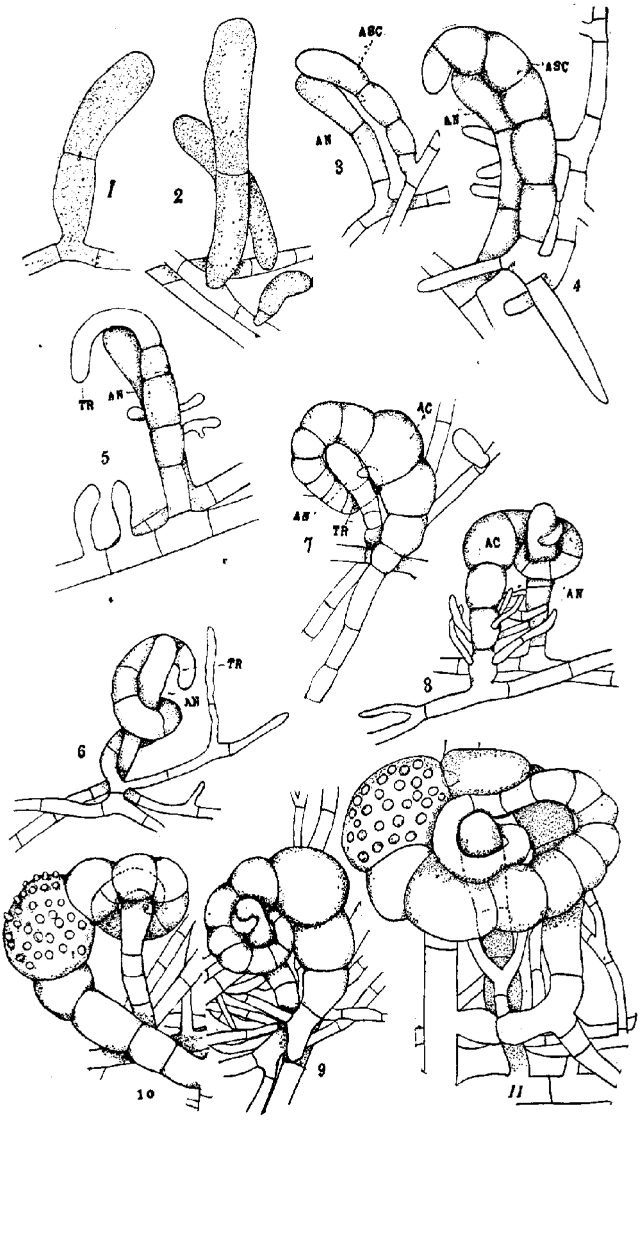
cellular trichogynes of the lichens and other Ascomycetes function in sexual reproduction. These structures have arisen through "progressive sterilization" and are taking on more and more vegetative functions now that sexuality has been lost. About the time Atkinson was formulating this theory, Killian (11) was publishing a preliminary paper on *Venturia* in which he says the nuclei from the antheridium pass into the trichogyne and travel down the long ascogonial coil, the cross walls of which disorganize. The theory of progressive sterilization of the trichogyne is thus overthrown immediately and completely in the event Killian's claim can be confirmed. I have not as yet seen his final paper on the subject (12). In a still later paper on *Cryptomyces* by the same author (13) there are reported other interesting discoveries, all of which, if true, go to show that one should not be too dogmatic in considering a subject such as the sexuality of the Asomycetes about which so little is really known. Little short of a screen demonstration of the passage of the male nuclei from the antheridium into the ascogenous cell will be accepted as final proof that the multiseptate trichogyne functions in sexual reproduction. There are those who deny that in *Pyronema* the simple one-celled trichogyne functions. Brown (2) claims that he studied a strain in which the trichogyne did not fuse with the antheridium at all. Unfortunately he lost this curious strain before his paper appeared in print.

THE ORIGIN OF THE ASCOCARP

In a fertile culture from four to six days old, one can find short one- or two-celled club-shaped branches growing in an erect or oblique position at the surface of the medium. They may be scattered about singly in certain regions (Text fig. 1) or they are more commonly associated in pairs, and sometimes in groups of three or four, all very much alike (Text figs. 2–5). In a very few hours some of the paired branches elongate (Text fig. 4). Both members may be somewhat curved and inclined, one slightly above the other (Text fig. 5). In such case the lower one ceases to elongate and remains a slightly curved two- or three-celled antheridium. Very frequently, however, both structures arise at

a short distance apart; one remains erect, the other elongates rapidly, forming a trichogyne which grows out and circles widely about the antheridium, drawing it up into the coiled portion, the end of which coils tightly about the end cell of the antheridium and fuses with it (Text figs. 8, 10). The habit of growing erect on the surface of the medium is a hindrance to making photographs or camera lucida drawings of the primordia as they develop. The ascogonia are always knocked over on the antheridium and flattened down when a cover glass is used.

It is not at all difficult to prove in every normal case that this club-shaped antheridium is present. By using a high-powered binocular microscope and a pair of the finest dissecting needles, or needles made of glass drawn out, the antheridium can be pulled out of the trichogyne coil provided fusion has not yet taken place. In Pl. 7, figs. 1 and 3, are shown photographs of a pair of young primordia with different magnifications, and figs. 2 and 4 show the same pairs after the antheridium has been pulled out of the encircling trichogyne coil. No fusion has taken place; the antheridium is plump and the contents are granular. An attempt to separate the organs in later stages, that is, after fusion of the cells, always results in a rupture of the trichogyne, sometimes the break occurring adjacent to the ascogenous cell (Pl. 7, fig. 7). In most cases short hyphal branches soon grow out from the stalk of the ascogonium and wrap about the stalk of the antheridium, so that it is impossible to separate the primordia (Pl. 7, figs. 5, 7, 8 and text fig. 8). This evidently is a further provision for maintaining the erect habit. It seems that there are two phases in the life of this species when an abundance of air is necessary, first at spore germination and second at the origin of the ascocarps. Only those ascospores germinate that lie on the surface of the medium and primordia never form beneath the surface of the agar. *A. Winteri* and *A. carbonarius* are indifferent to the amount of air at both of these periods. The ascogenous cell, which can soon be recognized, begins to enlarge rapidly (Text figs. 7, 8, 9, and Pl. 7, fig. 9) and ascogenous hyphae grow out in considerable numbers sometimes before sterile hyphae have begun to bud out to form the fruit body. (Text figs. 10, 13, 14, 15.)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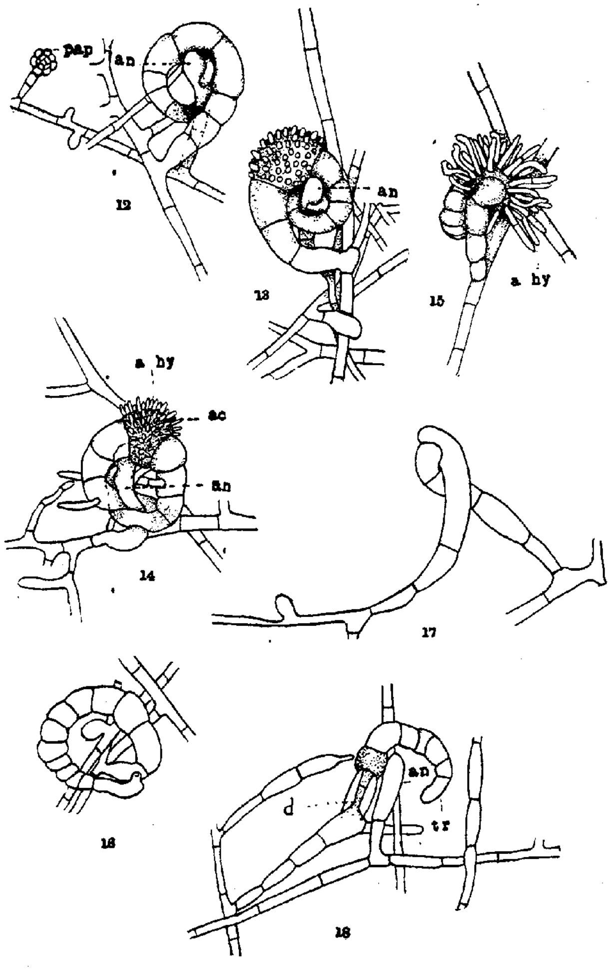
The form which the ascogonium takes as it develops depends greatly upon the position of the antheridium. Cases are illustrated in Text fig. 6 and in Pl. 7, fig. 6, in which the ascogonium becomes spirally coiled about the antheridium. In the latter figure the end of the trichogyne is plainly visible as it coils about the end of the antheridium. The type shown in Pl. 7, figs. 5, 8, is very common and fig. 10 shows another fairly common type in which the trichogyne makes a wide sweeping coil and the end runs upward along the antheridium (Text figs. 12, 14). Text fig. 15 shows a form in which the ascogenous hyphae have grown out to a considerable length before a single sterile hypha has appeared from the stalk of the ascogonium. The antheridium arises from the hypha crossing beneath from an oblique angle so that it is not shown in the figure. A rather complicated system is shown in Text fig. 11, in which it is difficult to determine the origin of the antheridium, and the trichogyne seems to be unnecessarily long. The antheridium is frequently quite a distance away and it may be that there is an inherent tendency to develop a long trichogyne even in cases where the antheridium grows nearby. In the specimens illustrated in Text fig. 10 the antheridium is really at some distance from the ascogonium, but the preparation was crushed down with a cover glass so that the ascogonium fell over on the antheridium as it always does in mounting the primordia. The camera lucida drawings reproduced in the text were made eight years ago from material preserved for a time in glycerine and then mounted in glycerine jelly. These preparations are very transparent, flattened out and distorted, still the essential features can be made out. Better preparations were made this

TEXT FIGS. 1–11. 1. A single two-celled primordium. 2. A group of three structures, two of which may pair up. 3. A typical pair of primordia, both curved, one lying slightly above the other. 4. The ascogonium arises from the end cell of a hypha and curves over the antheridium. 5. Trichogyne beginning to coil about the antheridium, the ascogenous cell not yet differentiated; sterile hyphae are growing out of the stalks of the primordia. 6. Spiral archicarp. Compare with fig. 6 in Plate 7. 7. Fertilization has taken place; the ascogenous cell is differentiated. 8. Outgrowth of sterile hyphae from the base of the archicarp. 9. The most common type of primordia. 10. Ascogenous hyphae beginning to grow out. These primordia are exceptionally long-stalked. 11. Complicated coil with a long trichogyne.



TEXT FIGS. 12–18. 12. *Papulospora* on the same hyphae with the antheridium. 13. Club-shaped aborted structure near functional primordia. 14. Shows a trichogyne somewhat entangled coiling about the antheridium and the stalk of the ascogonium; ascogenous hyphae well advanced. 15. Long ascogenous hyphae have grown out before the sterile hyphae from the stalk of the

year by mounting primordia directly from Flemming's weak fixative (after washing) into glycerine jelly. The darkening effect of the fixative is an aid in photographing the primordia.

I have previously described the young apothecium (8), pointing out that the hymenium is never covered by a pseudoperidium of sterile cells, such as we find in *A. furfuraceus*. *A. magnificus* is exactly like *Pyronema* in this respect. That an apothecium is "at first closed, then opens," in various ways or that the "hymenium is exposed from the first," these are specific but not necessarily generic or family characters in the Discomycetes.

In any fertile culture there can be found a great number of aborted ascogonia. The trichogyne may sometimes be unable to connect with the antheridium (Text fig. 16), or this structure may not mature sufficiently. In Text fig. 18 a good antheridium is shown to have developed but something evidently prevented fertilization. The paired structures shown in Text fig. 17 did not develop completely. Owing to the large size of apothecia of this species only a relatively small number reach maturity in any one culture, but hundreds of primordia are developed in dung cultures and large numbers of apothecia begin growth without maturing unless the older apothecia are removed or die out. Occasionally I have found that the ascogonium affects a weak union with a club-shaped structure developing on the same hypha, suggesting that rarely both sex organs may arise from the same hypha, and other cases where the trichogyne becomes attached to the stalk cell of the ascogonium (Text fig. 16). All such irregularities or abnormalities appear to come to nothing. In most of my text figures the hypha bearing the antheridium appears to lie below that from which the ascogonium arises. This is not necessarily true for every case, as the fertile hyphae may run parallel to each other or the branch bearing the antheridium may lie uppermost and run at any angle to the other.

ascogonium have made their appearance. The antheridium arises from the hypha crossing at an angle. 16. An aborted archicarp, the trichogyne appears to have become slightly attached to the basal cell of the archicarp. 17. A pair of aborted structures such as are frequently found in cultures. 18. "Durchwachsung," the stalk of the archicarp. A well-developed antheridium is present but the trichogyne did not function for some reason.

In such forms as *A. Winteri* and *A. furfuraceus* fully developed normal ascogonia can be found on hyphae where there is no indication whatever of a structure which in any way resembles an antheridium. I am convinced that these species do not possess morphological antheridia, although fertilization may take place in some other fashion. There can be no question, however, of the necessity for both kinds of sex organs in *A. magnificus*. This cannot be over-emphasized, since many students of the Ascomycetes are inclined to accept the view that sexuality exists in only a few forms like *Pyronema* and the powdery mildews.

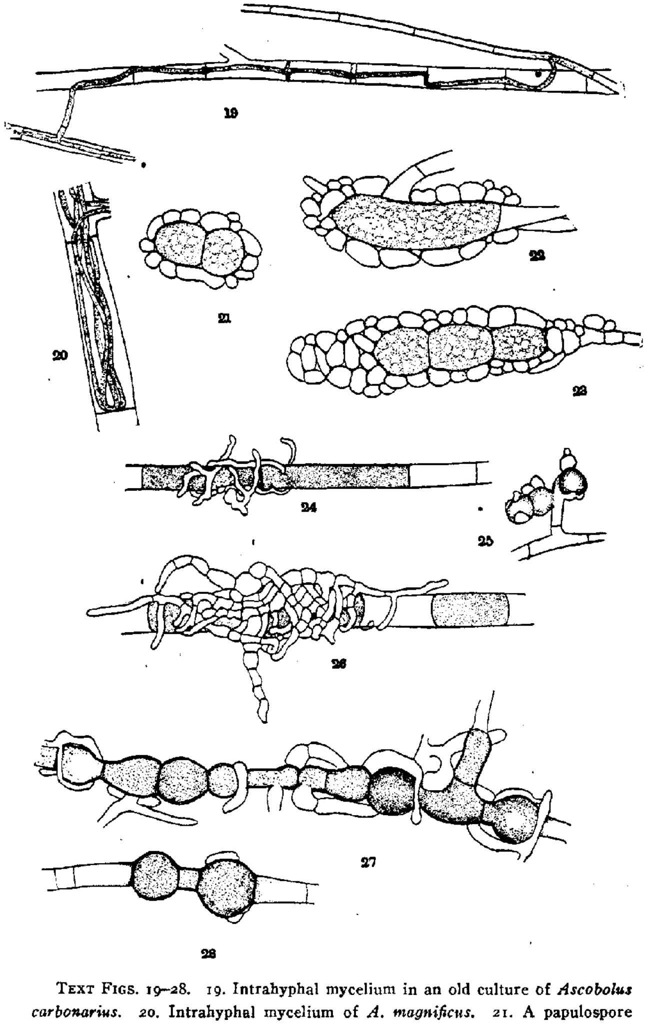
The primordia are visible even without a hand-lens and it is possible to determine within a few hours just when they will first make their appearance in the Petri dish culture. Flemming's weaker fluid is then poured into the dish which can be set aside for examination at leisure. The circle of agar can be floated out into a large battery jar, where it can be washed to remove the fixative previous to mounting the primordia in glycerine jelly. It is much better to study them while they are covered with Flemming's if one is interested in tracing the hyphal connections with them. An oatmeal agar or a potato agar is favorable for the production of large numbers of papulospores or large amounts of mycelium, but the starchy media should not be used if ascocarps are desired. I have dissected a very large number of primordia and have not found a single case where a normal, vigorously growing ascogonium was not accompanied by an antheridium and this is a pretty good indication that there is one species of *Ascobolus* at least in which the sexuality has not been lost or reduced.

We may now turn to the asexual method of reproduction of this species. Many common species of *Ascobolus* in Europe and America are, so far as reported, devoid of asexual spores. *A. parasitica,* described by Van der Wolk (14), is said, on little evidence, to possess a Sclerotium stage as well as a *Rhizostilbella* stage. I have described the curious spore-like bodies that grow in pure cultures of *A. carbonarius* (5). The ascogonia arise directly from certain of these "spores," but further study will be necessary to settle the question as to the exact nature of the others.

PAPULOSPORA MAGNIFICA

A very good illustration of the inadequacy of a classification of fungi based on asexual stages is the genus *Papulospora* as understood by Hotson (3). A true papulospore might be defined as one in which one or two large central storage cells are surrounded by a covering of hyphae which develop from blister-like outgrowths of the storage cell. Hotson has described a number of species and points out that these forms may belong to perfect stages of species in various groups of fungi, that is, *Papulospora* is the bulbil asexual stage liable to be found anywhere among the Ascomycetes.

Papulospores of the type shown in Plate 8, figs. 5, 6, 7, and Text figs. 21, 25, appear in about ten days in all cultures of *A. magnificus* which I have obtained by germinating ascospores. The spores are very hard to germinate, but I have been able to make hundreds of "pure" cultures, many of them one-spore cultures. The papulospores do not germinate readily, either, so that I have made only a few cultures by growing them. I have transferred the mycelium of these one-papulospore strains to several kinds of media without being able to obtain the ascocarps of the *Ascobolus*. At my request Professor J. W. Hoston made an extensive study of the *Papulospora* and published his results describing the species as *P. magnifica* (4). He was unable to obtain ascocarps from the culture which I sent him, and therefore concluded that there was not sufficient evidence to warrant assuming without further proof that it might be an asexual stage of *A. magnificus*. He thought it might occasionally be an intrahyphal parasite as I had once imagined (7). Mr. E. S. Schultz also made a pure one-spore culture of this *Papulospora* for me. I was unable to obtain ascocarps by growing this strain in various media. *Papulospora* stages have been connected with the Melanosporas and there is a very close resemblance between the bulbils of *P. magnifica, P. candida, P. parasitica, P. coprophila* and those of the Melanosporas studied by various investigators.



TEXT FIGS. 19–28. 19. Intrahyphal mycelium in an old culture of *Ascobolus carbonarius*. 20. Intrahyphal mycelium of *A. magnificus*. 21. A papulospore of *A. magnificus* with 2 central cells. 22, 23. Chains of storage cells (papulospores?) surrounded by small hyphae. Such bodies are of frequent occurrence

INTRAHYPHAL MYCELIUM

In old plate cultures it is not difficult to find internal hyphae running back and forth, in and out of the larger hyphae (Pl. 8, fig. 2 and Text fig. 20). Papulospores sometimes arise directly from branches growing out of these internal hyphae. It is only recently that I have been able to prove positively that this is not a case of parasitism of *Papulospora* on *Ascobolus*. On the contrary, it is simply a good example of what has been described under various names, such as Durchwachsungen, cordon interne, accroissement perforant, etc. In old cultures of certain fungi, one can find where bridging hyphae grow out from living cells through dead ones (Pl. 8, figs. 1, 3, 4), and connect up with the next living cells. It is said that a new wall may be formed about the reduced cytoplasm of an old cell, thereby constructing a new hypha of a shorter diameter which occupies only a small portion of the old cell cavity (31). It may happen that for long distances the cells of the hyphae degenerate so that the bud that grows out to bridge the gap must pierce many cross walls (Pl. 8, fig. 2 and Text fig. 19). We thus have what looks like the intrahyphal mycelium of a fungus parasite or a case where a fungus is parasitic on itself. The cross walls of the internal hyphae do not in any way correspond to those of the outer hypha whose septa not infrequently become almost invisible. Sometimes the internal hypha, unable to penetrate the cross wall at the first point of contact, runs along the wall to the other side where it may be able to push through, if not it returns through the same old cell and winds about several times before growing out into the medium. There is usually a swelling on the internal hypha where it passes through a septum of the big cell. De Bary describes *Cicinnobolus* as an intrahyphal parasite of the powdery mildews. Many persons who have investigated the subject of Durchwachsungen have remarked on the close re-

in old cultures on a dung decoction agar. 24, 26. Surface views of heavy-walled brownish cells surrounded by entangling hyphae. 25. Young papulospore that will eventually possess three central storage cells. 27, 28. Chlamydospore-like storage cells, papulospores?.

semblance to parasitism. As Zopf (20) says, "Oft sind entleerte Fäden auf weite Strecken hin von vielfach hin und her gebogenen Keimschläuchen ganz ausgefüllt. Fast möchte man angesichts solcher Bilder glauben, man habe einen fremden Organismus vor sich der als Parasit in den Chaetomienhyphen hause." Text fig. 19 is from an old culture of *A. carbonarius* where there can be no question as to the nature of this internal hypha. Various examples of this phenomenon are reported in the literature and I have arranged a number of the references in the following table:

TABLE I

REFERENCES TO SELF-PENETRATION, DURCHWACHSUNGEN, ETC.

Author	Date	Species
Gasparrini	1856	*Lemna minor*
Schleiden	1872	Saprolegniaceae
Kny & Magnus	1879	Marchantiaceae
Pringsheim	1873	*Saprolegnia*
Kny	1873	*Dasya, Hypnea*
Zopf	1881	*Chaetomium*
Brefeld	1881	*Ascoidea*
Borzi	1885	*Inzengeae*
Holterman	1885	*Ascoidea*
Lindner	1887	*Epicoccum, Alternaria, Botrytis*
Rothert	1892	*Sclerotium hydrophilum*
Klöcker & Schönning	1895–98	*Dematium pullulans*
Ternitz	1900	*Ascophanus carneus*
Duggar & Stewart	1901	*Rhizoctonia*
Beauverie & Guilliermond	1904	*Botrytis cinerea*
Molliard	1904	*Morchella esculenta*
Appel & Bruck	1906	*Sclerotinia libertiana, Botrytis*
Guilliermond	1908	*Gloeosporium nervisequum*
Lewis	1909	*Griffithsia*
Dodge	1912, 1915	*Ascobolus magnificus*
Dodge	1918	*Gymnosporangium*

When the teleutospores of species of *Gymnosporangium* are formed the young spore buds often grow into and through the old buffer cells above (36). If the intrahyphal mycelium found in the powdery mildews is that of a fungus parasitic on another fungus, then it is the only case of the kind known. All of the other examples of this phenomenon have been proved on further investigation to be due to self-penetration, "Durchwachsungen," "d'accroissement perforant," or self-parasitism, so to speak.

Compare Neger's figures of *Melanospora marchica, Papulospora* stage (15) with my figures, Pl. 8, also compare the "groups of chlamydospore-like structures" of *M. papillata* (Hotson, Pl. 2, fig. 7) with my text figures 22 and 23; and further, the "*Acremoniella* type" of spore of *M. cervicula* (Hotson, Pl. 3, fig. 17) with those shown in text figs. 27, 28, and one is struck with the close parallelism between the asexual reproductive bodies of *Melanospora* and those of *Ascobolus magnificus* and the spore balls of *Urocystis* type. As noted we have been unable to obtain ascocarps from one-spore cultures of *P. magnifica*. Furthermore, I have no record of obtaining ascocarps from a one-ascospore culture of *A. magnificus*.

TWO STRAINS NECESSARY FOR SEXUAL REPRODUCTION

I have stated in connection with the description of the primordia that the ascogonia and antheridia ordinarily (or perhaps always) arise from different hyphae. This fact early suggested the reason for the sterility of one-spore cultures. If one sows ascospores in a dung culture he may obtain ascocarps. If they are sowed in an agar medium under proper conditions germination may take place rarely, and I have frequently obtained ascocarps from such cultures, but I have noticed that when one or two transfers of mycelium are made from these fertile cultures the subcultures are apt to be sterile. This is especially true where the ends of the hyphae are cut off and transferred from young cultures. I have planted a single spore on agar in petri dishes and on sterile dung in jelly glasses in several hundred cases without obtaining a single germination, so rarely do the ascospores germinate. On August 16, 1919, I planted ascospores on agar in each of ten petri dishes, heating the cultures at 60° C. for twenty minutes. After twenty-four hours no germination had taken place. On September 2, mycelium was found in seven of the dishes and papulospores were present in each case, but there were no primordia or ascocarps. Transfers of mycelium were made to tube and plate cultures and on September 4 sterilized horse manure in jelly glasses was inoculated with the strains numbered 1, 2, 3, 4 and 5. Strain 6 was lost and strain 7 was

not used. Strain 2 was planted alone and in combination with strains 1, 3, 4 and 5, with the result that in ten days numerous ascocarps appeared on the cultures containing strains 2 + 1 and 2 + 4, while in the cultures containing strains 2, 2 + 3 and 2 + 5,

TABLE II

SUMMARY OF CULTURES OF *Ascobolus magnificus* FROM VARIOUS COMBINATIONS OF STRAINS—1, 2, 3, 4, 5, AND 7

Medium	No. of Cultures	Strains Used	Results[1]	
			Positive	Negative
Sterilized fresh horse manure in jelly glasses and milk bottles	26	2	0	26
	7	1	0	7
	3	3	0	3
	21	4	0	21
	3	5	0	3
	5	7	0	5
	7	2+1	6	1
	2	4+1	0	2
	3	2+2	0	3
	2	2+3	0	2
	22	2+4	21	1
	2	2+5	0	2
	3	2+7	2	1
	3	3+4	3	0
	2	4+4	0	2
	3	5+7	3	0
Horse dung decoction agar in Petri dishes	3	1+1	0	3
	3	1+2	3	0
	1	1+4	0	1
	1	1+5	1	0
	1	1+7	0	1
	36	2+2	0	36
	1	2+3	0	1
	52	2+4	52	0
	5	2+7	5	0
	1	3+3	0	1
	2	3+4	2	0
	40	4+4	0	40
	3	4+7	0	3
	5	5+4	5	9
Horse dung decoction agar in 12-in. test tubes	28	2	0	28
	5	2+2	0	5
	26	4	0	26
	3	4+4	0	3
	20	2+4	19	1
	5	1	0	5
	3	3	0	3
	6	5	0	6
	5	7	0	5

1 Results are positive when ascocarps appear in cultures, and negative when no ascocarps appear within a month.

there were no fruit bodies although papulospores could be found in all of the cultures. The last three cultures have not produced ascocarps. The following table shows cultures of which a record was kept in testing out the strains. Many others were made simply to obtain primordia for purposes of study.

It is clear that at least for these strains each is sterile by itself or strains 2, 3 and 5 are sterile (in the combinations tested) when placed together, as are strains 1, 4 and 7, but a combination of any one of either group with any one of the other group produces a fertile culture. I have since obtained ten new strains from germinated ascospores. These strains fall into two groups, two of which are like the original No. 2 and eight are like No. 4.

The use of sterilized fresh horse manure in jelly glasses or in milk bottles is preferable when it is simply desired to ascertain whether single strains ever become fertile because this is the natural substratum and the ascocarps reach a large size whenever the culture is fertile. On the other hand, when the fertility of two strains in combination is to be tested one of the transfers may not grow and it is then impossible to draw any conclusions whatever from negative results. Whehever papulospores are found it is certain that one strain has developed a mycelium, while the other may not have grown at all. On the other hand, plate cultures obviate this difficulty since it can be seen (within 24 hours) whether either strain has begun to grow, and if one has not a reinoculation can be made. No single strain culture on dung is reported sterile in the above table where an examination was not made to find papulospores, thus proving that the inoculation was successful. Twelve-inch test tubes containing the dung decoction agar are most satisfactory for keeping pure cultures for a long time. Ascocarps up to a centimeter in diameter have been grown in these large tubes, while I have not been very successful in growing ascocarps in small test tubes.

Not all of the possible combinations of strains 1, 2, 3, 4, 5 and 7 have been tried in these different ways, because the first thing desired was a combination that was sure to produce primordia for purposes of study. Strains 2 and 4 were chosen for the most extensive tests, and it can be said that each is sterile by itself and

fertile in combination with the other after many transfers. The first sub-cultures of strains 2 and 1 on dung in jelly glasses remained sterile from October 10 to January 6, but produced ascocarps within five days when both strains were grown together on dung in a milk bottle.

Behavior of Mycelia in Culture

If a petri dish culture is inoculated on opposite sides with the same strain $(4+4)$, the mycelia grow out at the same rate from both sides until they meet along a straight line through the center. There is a narrow region between the two mycelia which remains comparatively free from hyphae as though there was an antagonism or repulsion between the two. Now, if opposite strains such as 2 and 4 are planted in the same culture, the mycelia grow out at about the same rate, meeting near the center of the culture where there appears to be, for a brief period a slight antagonism, at least the rate of growth is much reduced, then the hyphae from either side can be found growing freely across the line of meeting, making a zone plainly visible across the center composed of hyphae from both strains. Numbers of ascogonia and antheridia soon make their appearance, not necessarily at all in a line across the center, such as one finds in the cultures of *Rhizopus*. The hyphae grow so rapidly that both strains are soon found throughout the culture and ascocarps appear in any region whatever. The largest numbers of sex organs, however, generally appear first near the line of meeting of the mycelia and one or two cm. from the periphery.

In view of Blakeslee's discoveries of plus and minus strains in the Zygomycetes and his theories regarding their sexuality, and Burger's recent report on the "pseudo-heterothallic" condition in *Cunninghamella* (15a), it is of importance to determine the question of the sexuality of the strains in this *Ascobolus*. Each of the strains so far isolated is self-sterile, and no sex organs are produced in a one-strain culture. Ascogonia and antheridia ordinarily arise from different hyphal branches. How universal this rule is, I am not prepared to say. I have not seen any good evidence of fertilization between structures arising

side by side on the same hyphal branch. The hyphae of this species are large and they can be traced for long distances in a transparent dung-decoction agar. Anastomoses occur frequently in fertile cultures near primordia, but the question of the sexuality of the strains will not be a difficult one to determine.

Shear (9) has studied species of the genus *Glomerella* and made large numbers of one-spore cultures from ascospores and conidia. He finds that many such strains are fertile in themselves, while others are sterile. He has grown various strains and cultures together without obtaining evidence of what might be called plus and minus strains. Edgerton (10), however, states that he has repeatedly isolated plus and minus strains of *Glomerella* from one-spore cultures. One strain when planted alone produces some perithecia as will the other when it is grown by itself, but when both plus and minus strains are grown together there is a dense black line of perithecia formed where the strains meet. There are, however, perithecia scattered about elsewhere in the culture. Edgerton was unable to find structures corresponding to oögonia and antheridia; however, he offers a theory to account for the behavior of his strains.

No sex organs are developed in the strains of *Ascobolus magnificus* mentioned above except under the contact or chemical stimuli of two strains in the same culture. Are archicarps formed on one strain and antheridia on another? Will each strain remain self sterile indefinitely? Are strains segregated at the time of ascospore formation? Are there neutral strains or pseudo-heterothallic strains? All of these questions remain interesting subjects for further investigation.

Summary

1. The ascocarp of *Ascobolus magnificus* originates from a pair of morphologically distinct primordia—a large ascogonium the end of which functions as a trichogyne, and a club-shaped antheridium.

2. *Papulospora magnifica* Hotson is an asexual stage of *Ascobolus magnificus* Dodge.

3. The intrahyphal mycelium found in old cultures is simply a case of "Durchwachsungen," or "cordon interne."

4. The strains here reported, which were obtained from germinated papulospores or ascospores, were self-sterile in the experiments conducted, but always produced papulospores.

5. Sexual reproduction occurs in cultures containing two strains properly chosen.

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EXPLANATION OF PLATES

PLATE 7

Fig. 1. Primordia before fertilization, trichogyne not fully developed.

Fig. 2. The same pair of primordia after the antheridium had been pulled out of the trichogyne coil.

Figs. 3 and 4. Same as Figs. 1 and 2 except less highly magnified. The coiled portion of the ascogonium (trichogyne?) shows more distinctly in this position than in Fig. 2.

Figs. 5 and 8. Common types of primordia in which the antheridium is *circled by sterile hyphae from the stalk of the ascogonium.*

Fig. 6. Spiral type in which the trichogyne is plainly visible coiling about the end of the antheridium.

Fig. 7. Archicarp broken in two in an attempt to pull the antheridium away from the trichogyne after fusion had taken place.

Fig. 9. Short-stalked archicarp, the antheridium not visible.

Fig. 10. Same type as shown in Fig. 9 except that the antheridium is plainly visible.

PLATE 8

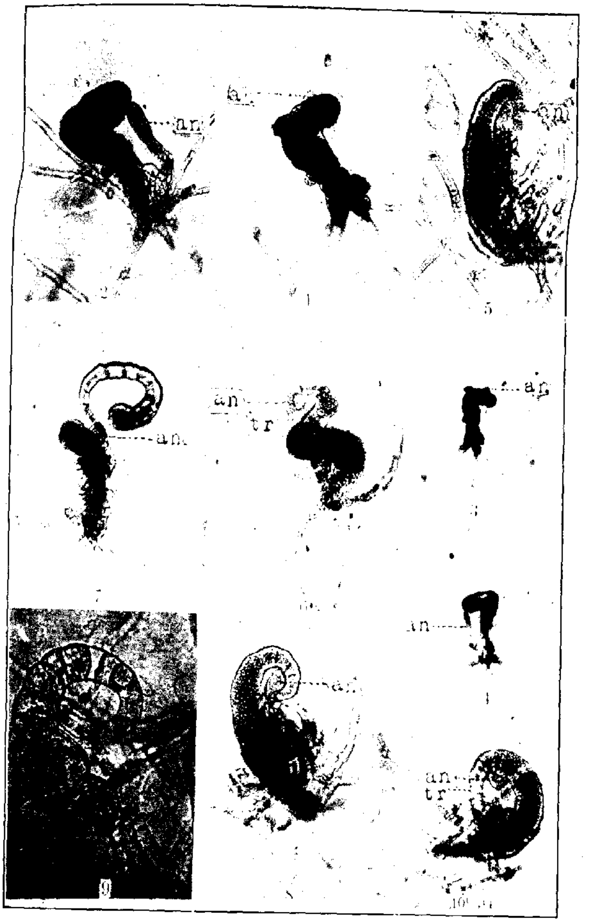
Fig. 1. Hyphae bridging a dead cell and connecting two living cells.

Fig. 2. Intrahyphal mycelium resembling the mycelium of a fungus parasite.

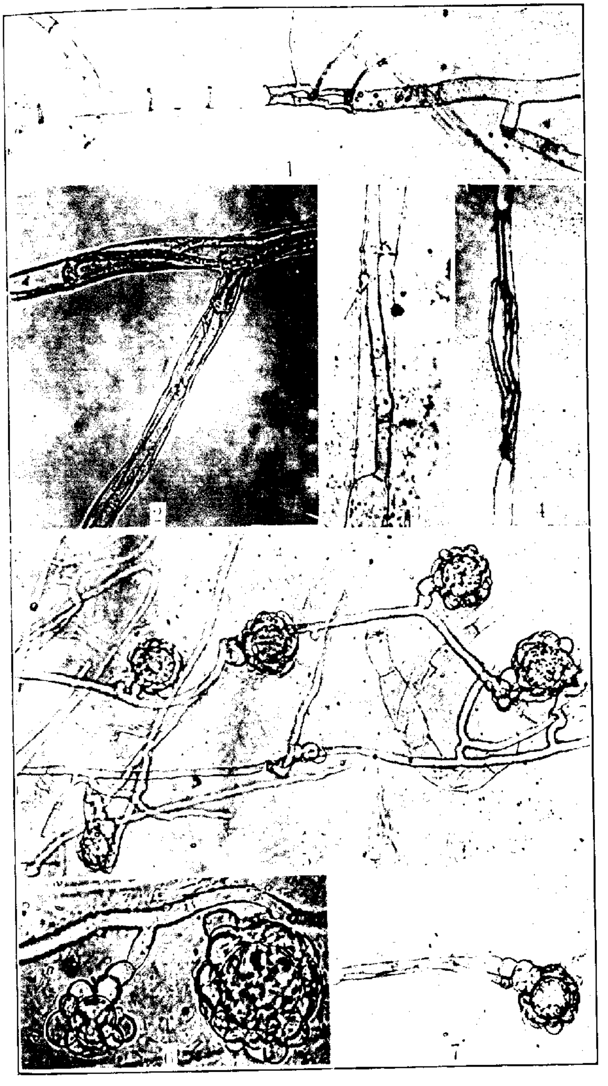
Figs. 3 and 4. Clearly the "Durchwachsung" type of bridging hyphae.

Figs. 5 and 6. Papulospores of *Ascobolus magnificus.* At the right in Fig. 5 can be seen a few cells of a hypha of large diameter. Note the small hyphae from which the papulospores arise. This is not always the case as these spores frequently arise from hyphae of large diameter.

Fig. 7. Papulospore arising from an "internal hypha."



ASCOBOLUS MAGNIFICUS DODGE



Ascobolus magnificus Dodge

SOME MYCOLOGICAL NOTES FOR 1919*

L. O. OVERHOLTS

(WITH PLATES 9 AND 10)

The fungous flora of the mountains of central Pennsylvania is perhaps as rich and as varied as in any other region of the United States. The summer of 1919 was marked by an unusual abundance of rainfall that brought forth such a crop of fungi as had not been produced since 1915. Intensive and extensive collecting over several years has added scores of hitherto unreported species to the fungous flora of the state. A considerable number of these are of rare occurrence or for other reasons are only imperfectly known. It is hoped that the present paper with the accompanying photographs will help to give these few species a more prominent place in the mycological literature of the country.

1. CLAVARIA ORNATIPES Peck

The writer has collected Clavarias in considerable abundance for several seasons past, but this is the first collection of this interesting species. The name of Peck's species *C. bicolor* (later changed to *C. vestitipes*) for a different plant, would fit this plant nicely, for the color contrast between the drab-gray branches and the wood-brown (Ridgway's colors) stem is quite marked. Persoon's name, *C. trichopus*, for a similar if not identical plant, refers to the abundant ascending gray-brown stiff hairs that clothe the stem. *C. vestitipes* Peck is a much smaller plant. *C. krombholzii* Fr. (ex Lloyd) is similar in stature and branching but uniformly white in color. The spores of my specimens are globose, smooth, hyaline under the microscope, and measure 8–10 μ in diameter. The content is quite granular.

* Contribution from the Department of Botany, The Pennsylvania State College, No. 22.

2. CRATERELLUS PISTILLARIS Fr.

This interesting species was collected in abundance in the Seven Mountains of Center County, on August 24. About 25 specimens were found along an old forest trail in the vicinity of Bear Meadows. Dr. Burt reports[1] but three localities in this country, viz., New Hampshire, Vermont, and Michigan for the species. Professor E. T. Harper has published[2] some excellent illustrations and given some critical notes on the species.

My plants were somewhat larger than the measurements recorded by Dr. Burt, the largest specimens being 16 cm. tall and 7 cm. thick at the apex. A few specimens were somewhat compressed and flabelliform in shape and one specimen was strongly 2-lobed at the apex. The color of the nearly smooth hymenium varied from light pinkish cinnamon to vinaceous cinnamon of Ridgway. The specimens grew in a mixed hard-wood forest, chestnut and oak predominating.

3. FOMES BAKERI (Murrill) Sacc.

Plate 9, figs. 1, 2

On species of birch in the middle-western United States there has been known for some time a *Fomes* that by most collectors was referred to *F. igniarius* Fr. In 1908, Murrill[3] described this as a new species under the above name and later reported[4] its range as "Wisconsin, Missouri, and westward." In 1915, Lloyd referred[5] this plant as a variety of *F. robustus* Karst., known in this country only from California. The writer added[6] an Ohio locality in 1915 and pointed out that while the type collection was made by C. F. Baker, yet the plant distributed under that name by him in Plants of Southern California, 5188, was a different species, probably *Polyporus gilvus*.

On the basis of these references the species was not believed to occur east of the Appalachian Mountains, and it was with con-

[1] Ann. Mo. Bot. Gard. 1: 342. 1914.

[2] Mycologia 5: 263. 1913.

[3] N. Am. Flora 9: 104. 1908.

[4] Northern Polypores, p. 48. 1914.

[5] Synopsis of the genus Fomes, p. 243. 1915.

[6] Polyporaceae of the Middle-Western United States, p. 61. 1915.

siderable surprise that on November 22, 1919, a dead standing sweet birch (*Betula lenta*) was observed bearing a number of excellent sporophores of what proved to be this species. These are the largest sporophores yet seen, and some of them are more applanate than is usually the case. The largest specimen measures $13 \times 20 \times 5$ cm. The tree that bore these sporophores was about two feet in diameter and was later felled for observations as to the characteristics of the decay produced. It was found that the fungus is a sap-wood destroying organism, although perhaps encroaching to some extent on the heart wood. But in the center of the tree there was a cylinder of the dark red, sound heartwood characteristic of this species of tree. Pieces of the log containing both sapwood and heartwood were brought into the laboratory and at the present writing the fungous mycelium has grown out over the surface of the sapwood in a brownish-olive mat, but has not appeared on the adjacent heartwood. The decayed wood has no striking characteristics but the decay appears to be of the general delignifying type, whitening the wood and rendering it brittle but not friable. This habit of being largely confined to the sapwood serves to emphasize the distinction between this species and *F. igniarius*—a heart-rotting organism.

A search was then made in the herbarium material representing allied species of this fungus with the result that two additional collections were discovered, both from Pennsylvania. One was taken by Dr. A. S. Rhoads, on *Betula lutea* in Philadelphia, Pa., December 27, 1915, the other by the writer, on *Betula lenta*, February 24, 1918, in the mountains near State College. It is a curious fact that of the three Pennsylvania collections two were from trees growing on the exposed summits of mountain ridges, while in the state of Missouri the writer knew it as frequenting the birches in the lowlands along streams.

Plants of this species are not as firm and hard as is *F. igniarius*, and they lack the white incrustation found in the older layers of tubes of that species. In addition the tubes are distinctly stratified (see fig. 2) and the context has a decidedly silky luster similar to that in *Fomes everhartii*. These points serve to distinguish the species from its allies.

4. Merulius aureus Fr.

Plate 10, fig. 4

This is one of the more uncommon species of *Merulius*. An excellent collection was made October 5 on the decorticated trunk of a pitch pine (*Pinus rigida*) near State College. In these specimens the plant is largely resupinate but with a definite reflexed border in many cases. The largest specimen had a spread of 15 cm. in length and about 5 cm. in width. The color of the young plant, or the growing margins of older resupinate specimens is buff yellow or light orange yellow. The color of the reflexed pileus is close to yellow ochre and varies from finely pubescent to glabrous. The color of the hymenium is not closely matched in Ridgway's Manual, being darker than zinc orange and too bright for cinnamon rufous. Xanthine orange is probably closer. The color is quite similar to that of *Paxillus corrugatus* and the configuration of the hymenium suggests a relationship with that plant. The absence of any odor, however, immediately corrects any impression that it might be that species. This collection shows quite well that when first formed the fruiting bodies are nearly orbicular and 0.5–1.5 cm. broad. They soon become laterally confluent to the measurements given above, but even in such specimens it is often possible to trace the limits of the original sporophores, as the folds are often sub-lamellate and radially arranged from the center. The spores are oblong or short-cylindric and sometimes pointed at one end, smooth, hyaline under the microscope, and measure $3–4 \times 1.5–2\,\mu$; cystidia none. Dr. Burt states that in mass the spores of the species are somewhat yellowish, but light spore falls obtained from these specimens are colorless.

5. Mucronella ulmi Peck

Plate 10, fig. 5

This peculiar plant has been found in considerable abundance for the first time since its appearance here in 1915. Its small size makes it very inconspicuous and easily overlooked. It grows on the bark on the north side of a living *Ulmus americana*

tree on the campus of the Pennsylvania State College. A lavender or purplish tint has been noted on the teeth this season.

The genus *Mucronella* is characterized by short awl-shaped teeth that arise directly from the substratum without the intervention of a subiculum. It thus approaches some of the small Clavarias in habit, and some would include the genus in the *Clavariaceae*. In some species, as the present one, the teeth are not separate but are united several in a fascicle, approaching the form of a diminutive *Hydnum erinaceum* or related species.

Mr. Lloyd has recently summarized[7] our knowledge of the taxonomy of the genus. He lists five species, four of which have been reported from the United States. Two of these are now known to occur in Pennsylvania. The plants are extremely rare, however, and no other account of the species of the United States has been published. I take this opportunity, therefore, to present a photograph and a few remarks concerning the species.

The genus as originally founded was said to have one-spored basidia. I have examined my material carefully but no spores or sterigmata were seen, though young basidia were abundant. The following descriptive notes are appended:

Plants white, drying gray, composed of few or several awl-like teeth, 2–4 mm. long, united by their bases into small clusters 2–4 mm. broad and 2–5 mm. long; spores not obtained; cystidia none.

On bark of living elm trees. October.

6. Paxillus corrugatus Atk.

A collection of this rare plant was made at Shingletown Gap, Center County, Pa., August 16, 1919, on the bark and wood of a fallen *Pinus rigida*. The species is easily recognized by the very strong odor and the corrugated gills that are near ochraceous buff (Ridgway) in color. The odor is very characteristic and unlike that of any other fungus. It has persisted until the present time in a Kentucky collection preserved in the writer's herbarium since 1909, when it was collected by Dr. Bruce Fink. Parts of the present collection were very largely resupinate.

[7] Mycological Notes No. 39, pp. 531–533. 1915.

The species was originally described from New York by Professor Atkinson. Kauffman also reports a station for it in *Michigan*.

7. POLYPORUS SCHWEINITZII Fr.

This polypore, rather common in Pennsylvania on conifers, especially species of pine, was collected near Boalsburg, Pa., on the roots of a living tree of *Quercus alba*. This is probably an unreported host for this species. The woods in which the specimen was taken is an open mature stand, consisting entirely of oaks and hickories, and there is no indication that conifers have ever been present in the wood lot.

8. PORIA SEMITINCTA Peck

This beautiful *Poria*, originally described by Peck[8] in 1879 and recently re-described by the writer, has hitherto been found, to the writer's knowledge, only in four localities in New York State. Its appearance in Pennsylvania is, therefore, of considerable interest. It was collected from the bark of an oak log, near State College, October 5, 1919. The specimens were fresh and on the young subiculum and the growing margin of nature plants the pinkish-lilac color was quite marked. This color has persisted in the dried plants up to the present time. There is also a slight "sweet-acid" odor to the fresh specimens, similar to that in *Polyporus galactinus* Berk. A few scattered cystidia are present in certain areas but often whole sections are without them. In agreement with this, they were reported by the writer as absent in the type specimens of this species but rarely present in another collection preserved at Albany. In the present collection they are 6–9 μ in diameter, project rather strongly, and are slightly incrusted. At first sight it was supposed that this collection might represent the resupinate condition of *Polyporus pargamenus* which on the growing margin is often a similar lavender or lilac color. The plants are too thin for that species, however, the spores are not allantoid but oblong or short-cylindric, the cystidia when present are different, and the hyphae of this plant are quite characteristic. No clamps are present, cross walls are

[8] Bull. N. Y. State Mus. 205–206, pp. 106–108. 1919.

abundant and conspicuous, and most of the numerous branches originate near a cross wall.

9. TREMELLA SPARASSOIDEA Lloyd

Plate 10, fig. 3

On August 25, the writer collected a large *Tremella* on the ground in a deciduous woods near State College. It was assigned tentatively to *Tremella vesicaria* and sent to Mr. C. G. Lloyd under that name. The fungus differs from that species, however, principally in having *acute* erect and *somewhat fimbriate* lobes instead of the large blunt finger-like ones characteristic of *T. vesicaria*. Mr. Lloyd proposes to describe this as a new species as named above. The entire plant formed a mass about 15 cm. in diameter and 10 cm. high and was nearly white in color. In consistency it was more cartilaginous than gelatinous, probably in part accounted for by the dry weather of the few days previous. The basidia are of the usual longitudinally divided type, averaging about $9 \times 12\text{–}14\,\mu$ and with sterigmata up to $20\,\mu$ long. All stages in the development of the basidia are easily found in crushed preparations. The spores are somewhat irregular in shape, from elongate-ellipsoid to broadly inaequilaterally ellipsoid though usually narrower and sometimes slightly apiculate at one end. They measure $8\text{–}10 \times 4.5\text{–}6\,\mu$. A specimen is preserved in the Lloyd museum and in the Overholts Herbarium.

In 1910, Gilbert noted and figured a plant from Wisconsin[9] that I have no doubt from his photograph should be referred here. He included it as a variety of *Tremella reticulata*, a name applied by him to the plant here called *T. vesicaria*. My photograph of *T. sparassoidea* shows a striking resemblance to the one published by Gilbert.

10. TREMELLA VESICARIA Fr.

This species was collected in abundance in a grassy woodland pasture in 1915, but had not since been observed until a speci-

[9] Studies on the Tremellineae of Wisconsin. Trans. Wisc. Acad. Sci., Arts, and Let. 16: 1137–1170. 1910.

men was brought in on July 22 of this year. It is undoubtedly to be considered as a rare species although apt to be abundant in local isolated regions.

11. TREMELLODON GELATINOSUM (Scop.) Fr.

About 25 specimens of this unique member of the *Tremellaceae* were collected by the writer on an old hemlock log in Bear Meadows, Center County, Pa., August 30, 1919. The species is apparently rather widely distributed but only rarely collected. The color of the upper surface when fresh varied from nearly white to drab or buffy brown (Ridgway). The largest specimens measured 6 × 7 cm. Another collection from New Hampshire is in the writer's herbarium. Very good illustrations are given in Hard's mushroom book, fig. 405.

12. TRICHOGLOSSUM HIRSUTUM (Pers.) Boudier

Collected in Bear Meadows, Center County, Pa., August 30, 1919. Several hundred individuals were found growing closely associated on a small area of earth, leaf mold, and rotten wood. The largest specimens were about 10 cm. tall and in some the ascigerous portion was somewhat convoluted. The stem and hymenium is beset with a multitude of spines that give a velvety appearance and feeling to the plant. The spores were uniformly 15-septate as described by Durand and measured 130–140 × 5–6 μ.

STATE COLLEGE, PA.

EXPLANATION OF PLATES

PLATE 9

Fig. 1. View of upper surface of a rather young sporophore of *Fomes bakeri*. × ½. In age the pileus may become considerably rimose. Overholts Herb. No. 5529. Photo by E. T. Kirk.

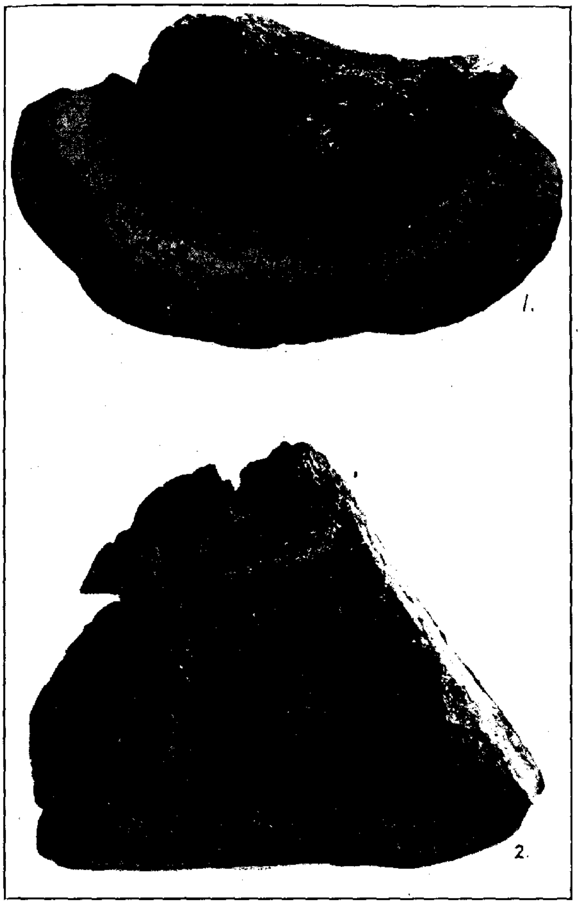
Fig. 2. Lateral view of a vertical section through a perennial sporophore. × 1. Note the conspicuous context and the marked layering of the tubes. Overholts Herb. No. 4174. Photo by E. T. Kirk.

PLATE 10

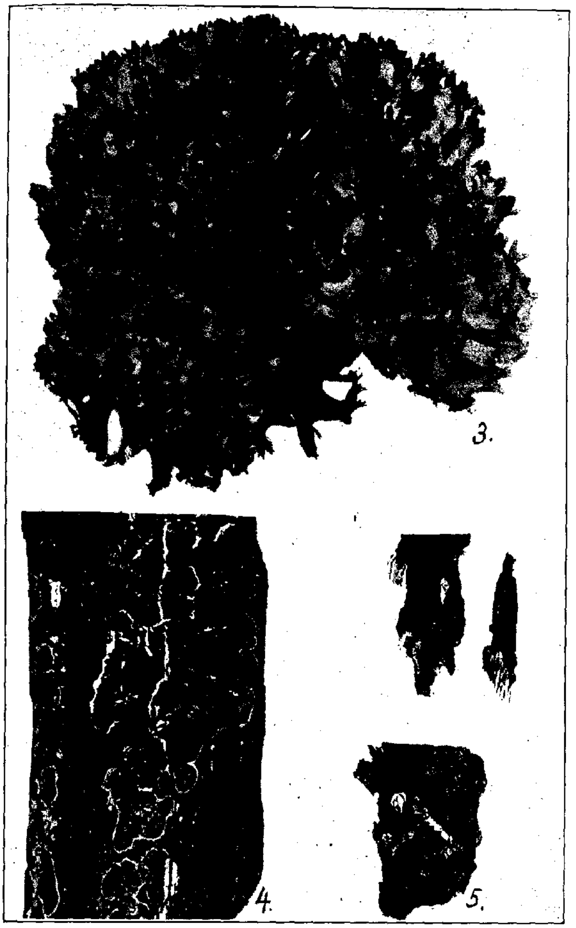
Fig. 3. *Tremella sparassoidea*. View, from above, of the entire plant. × ¾. Type collection, Overholts Herb. No. 5407. Photo by the writer.

Fig. 4. *Merulius aureus*. Specimens largely resupinate. × 1. Overholts Herb. No. 5455. Photo by E. T. Kirk.

Fig. 5. *Mucronella ulmi*. Specimens from bark of living *Ulmus americana*. × 1½. Overholts Herb. No. 3169. Photo by the writer.



FOMES BAKERI (MURRILL) SACC.



3. TREMELLA SPARASSOIDEA LLOYD
4. MERULIUS AUREUS FRIES
5. MUCRONELLA ULMI PECK

RUSTS FROM GLACIER NATIONAL PARK, MONTANA

Paul C. Standley[1]

During the summer of 1919, the writer spent ten weeks in Glacier National Park, under the direction of the National Park Service, for the purpose of securing data concerning the flora of the region. Attention was devoted almost wholly to the flowering plants and vascular cryptogams, but a few of the lower cryptogams were secured incidentally, and a small amount of time was spent in searching specially for rusts. Sixty-one species of these interesting plants were secured, and since they come from an area in which very little botanical collecting has been done, it may be worth while to publish a list of them. The list is particularly deficient in grass rusts, for grasses were not collected, and consequently the rusts that may have existed upon them were likewise neglected.

The writer is under obligations to Dr. J. C. Arthur, who has kindly determined the collections. The specimens are in the U. S. National Herbarium, and duplicates of most of them are in Doctor Arthur's herbarium.

The flowering plants of Glacier Park are of great interest. The flora of the east slope of the Park is similar to that of the central Rocky Mountains, but the flora of the west slope shows a marked relationship with that of the Pacific Coast. Many species of plants, especially of trees, find the eastern limit of their range there, and many plants which are common in Alberta and British Columbia extend into the United States in northwestern Montana, but are rare or absent elsewhere south of the international boundary.

The material collected during the season of 1919 has served as the basis of a popular account of the plants of the Park, to be issued by the National Park Service, and of a technical flora of the region, to be published by the National Museum.

[1] Published by permission of the Secretary of the Smithsonian Institution.

AECIDIUM ALLENII Clinton

I. On *Lepargyrea canadensis* (L.) Greene (15505).

ALLODUS PALMERI (D. & H.) Arth.

I, iii. On *Penstemon ellipticus* Coult. & Fish. (16759).

CALYPTOSPORA COLUMNARIS (A. & S.) Kühn

On *Pseudotsuga mucronata* (Raf.) Sudw. (16902). Dr. Arthur states that this rust has not been reported previously upon *Pseudotsuga*. It occurs usually upon species of *Abies*.

COLEOSPORIUM RIBICOLA (C. & E.) Arth.

II, III. On *Ribes lacustre* (Pers.) Poir. (15903).

COLEOSPORIUM SOLIDAGINIS (Schw.) Thüm.

II. On *Solidago concinna* A. Nels. (16915). ii, III. On *Aster meritus* A. Nels. (18686). III. On *Aster Fremontii* (Torr. & Gray) Gray (18425), and *Aster conspicuus* Lindl. (16935).

CRONARTIUM COMANDRAE Peck

On *Comandra pallida* A. DC. (15944).

GYMNOSPORANGIUM BETHELI Kern

I. On leaves of *Crataegus Douglasii* Lindl. (17844).

GYMNOSPORANGIUM GERMINALE (Schw.) Kern

On fruit of *Crataegus Douglasii* Lindl. (17416) and *Amelanchier alnifolia* Nutt. (17007).

GYMNOSPORANGIUM JUVENESCENS Kern

I. On leaves of *Amelanchier alnifolia* Nutt. (15597).

GYMNOSPORANGIUM NELSONI Arth.

I. On leaves of *Amelanchier alnifolia* Nutt. (17743, 17425, 15159) and *Sorbus sitchensis* Roem. (16533, 18449, 18643, 17034). Almost every plant of the mountain ash had rusted leaves. The yellow spots on the leaflets are conspicuous in early summer, but no aecia were found in 1919 until July 28.

HYALOPSORA CHEILANTHES (Peck) Arth.

On *Cryptogramma Stelleri* (Gmel.) Prantl (17144).

MELAMPSORA ALBERTENSIS Arth.

ii, III. On *Populus tremuloides* Michx. (18732). Seen only about Belton, although aspens are abundant on the east slope of the Park.

MELAMPSORA ARCTICA Rostr.

II, iii. On *Salix Scouleriana* Barr. (18485).

MELAMPSORA CONFLUENS (Pers.) Jackson

II, III. On *Salix Bebbiana perrostrata* (Rydb.) Ball (15699), *S. subcaerulea* Piper (15111, 18805, 18460, 17366), *S. monticola* Bebb? (17686), and *S. Scouleriana* Barr. (15971, 18736, 15969, 15606, 16680).

MELAMPSORA OCCIDENTALIS Jackson

II, III. On *Populus hastata* Dode (18765).

MELAMPSORELLA ELATINA (A. & S.) Arth.

II. On *Cerastium strictum* L. (15752) and *C. beeringianum* Cham. & Schlecht. (17479).

MELAMPSOROPSIS PYROLAE (DC.) Arth.

II. On *Pyrola chlorantha* Sw. (17924), *P. secunda* L. (16038), *P. asarifolia* Michx. (15206), and *Moneses uniflora* (L.) Gray (15241).

PHRAGMIDIUM ANDERSONI Shear

On *Potentilla fruticosa* L. (17360).

PHRAGMIDIUM IMITANS Arth.

II, III. On *Rubus strigosus* Michx. (16085).

PHRAGMIDIUM IVESIAE Sydow

II, III. On *Potentilla Nuttallii* Lehm. (15020, 17739). I. On *Potentilla monspeliensis* L. (15544a).

PHRAGMIDIUM OCCIDENTALIS Arth.

II, III. On *Rubus parviflorus* Nutt. (15196, 17928).

PHRAGMIDIUM POTENTILLAE (Pers.) P. Karst.

On *Potentilla pennsylvanica* L. (17324, 17336).

PHRAGMIDIUM ROSAE-ACICULARIS Liro.

I. On *Rosa Bourgeauiana* Crép. (15711). I, ii. On *Rosa nutkana* Presl (14967). III. On *Rosa gymnocarpa* Nutt. (18862, 17923) and *R. nutkana* Presl (18750).

PUCCINIA ABERRANS Peck

On *Smelowskia americana* Rydb. (16474, 15801).

PUCCINIA ABUNDANS (Peck) Jackson

I. On *Symphoricarpos albus* (L.) Blake (15674).

PUCCINIA ANTIRRHINI D. & H.

Occurring abundantly at Lake McDonald on cultivated snapdragons.

PUCCINIA ARNICALIS Peck

III. On *Arnica latifolia* Bong. (15899).

PUCCINIA ASPERA D. & H.

On *Saxifraga Mertensiana* Bong. (16814).

PUCCINIA ASTERUM (Schw.) Kern.

I. On *Aster frondeus* (Gray) Greene (15329, 14968) and *Erigeron macranthus* Nutt. (17978).

PUCCINIA BALSAMORRHIZAE Peck

On *Balsamorrhiza sagittata* (Pursh) Nutt. (15983).

PUCCINIA CIRCACEAE Pers.

On *Circaea alpina* L. (17078, 17937).

PUCCINIA CIRSII Lasch.

On *Cirsium Hookerianum* Nutt. (15705).

PUCCINIA CLEMATIDIS (DC.) Lagerh.

I. On *Thalictrum megacarpum* Torr. (15258, 14944, 15197) and *Halerpestes Cymbalaria* (Pursh) Greene (17622). II, III. On *Elymus glaucus* Buckl. (17962).

PUCCINIA FERGUSSONI B. & Br.

On *Viola palustris* L. (16493).

PUCCINIA FRASERI Arth.

On *Hieracium albiflorum* Hook. (16365).

PUCCINIA HEUCHERAE (Schw.) Dict.

On *Mitella nuda* L. (16492).

PUCCINIA HIERACII (Schum.) Mart.

On *Hieracium albiflorum* Hook. (15188) and *H. columbianum* Rydb. (16663, 18758).

PUCCINIA HOLBOELLII (Hornem.) Rostr.

On *Arabis Lyallii* S. Wats. (16231, 15419, 15838, 18036).

PUCCINIA MESOMEJALIS B. & C.

On *Clintonia uniflora* (Schult.) Kunth (15187).

PUCCINIA PIMPINELLAE (Schum.) Mart.

I, ii, III. On *Glycosma occidentalis* Nutt. (14923, 15927). II, III. On *Osmorrhiza divaricata* Nutt. (18480).

PUCCINIA RHAMNI (Pers.) Wettst.

I. On *Rhamnus alnifolia* L'Hér. (14951, 15266). II, III. On *Calamagrostis canadensis* (Michx.) Beauv. (16868).

PUCCINIA SAXIFRAGAE Schl.

On *Saxifraga rivularis* L. (18044a).

PUCCINIA TARAXACI Plowr.

II, III. On *Taraxacum officinale* Weber (15922, 18757).

PUCCINIA TROXIMONTIS Peck

III. On *Agoseris villosa* Rydb. (16080) and *A. turbinata* Rydb. (16662).

PUCCINIA URTICAE (Schum.) Lagerh.

I. On *Urtica cardiophylla* Rydb. (15237).

PUCCINIA VERATRI Duby.

On *Epilobium anagallidifolium* Lam. (15199, 16104) and *E. alpinum* L. (18024a).

PUCCINIA VIOLAE (Schum.) DC.

III. On *Viola canadensis* L. (15931, 17917).

PUCCINIASTRUM ARCTICUM AMERICANUM Farl.

II. On *Rubus strigosus* Michx. (18247).

PUCCINIASTRUM MYRTILLI (Schum.) Arth.

II. On *Vaccinium membranceum* Dougl. (18745, 18266, 16359), *V. caespitosum* Michx. (18818), and *V. Myrtillus* L. (16361).

PUCCINIASTRUM PUSTULATUM (Pers.) Diet.

On *Epilobium platyphyllum* Rydb. (17974), *E. angustifolium* L. (18775, 18478), and *E. adenocaulon* Hausskn. (16998).

PUCCINIASTRUM PYROLAE (Pers.) Diet.

II. On *Pyrola secunda* L. (18694). Collected also at Iceberg Lake, on *Pyrola minor* L., by Miss Gertrude Norton.

UREDINOPSIS ATKINSONII Magn.

II. On *Athyrium Filix-foemina* (L.) Roth (17918).

UROMYCES GLYCYRRHIZAE (Rabenh.) Magn.

On *Glycyrrhiza lepidota* Nutt. (18833).

UROMYCES HEDYSARI-OBSCURI (DC.) C. & P.

I. On *Hedysarum sulphurescens* Rydb. (16658).

UROMYCES HETERODERMUS Sydow

On *Erythronium grandiflorum* Pursh (16182, 18086).

UROMYCES INTRICATUS Cooke

I, II. On *Eriogonum Piperi* Greene (15595, 15980).

UROMYCES JUNCI (Desm.) Tul.

I. On *Arnica mollis* Hook. (16937).

UROMYCES POROSUS (Peck) Jackson

I. On *Vicia americana* Muhl. (15123).

UROMYCES SILENES (Schl.) Fckl.

III. On *Silene multicaulis* Nutt. (16586).

UROMYCES TRIFOLII (Hedw. f.) Lev.

II. On *Trifolium repens* L. (18863) and *T. hybridum* L. (18864).

UROPYXIS SANGUINEA (Peck) Arth.

II. On *Berberis repens* Lindl. (15189, 18872).

U. S. NATIONAL MUSEUM,
WASHINGTON, D. C.

NEW OR NOTEWORTHY NORTH AMERICAN USTILAGINALES

H. S. JACKSON[1]

TILLETIACEAE

TILLETIA SECALIS (Corda) Kühn, Bot. Zeit. 34: 471. 1876

Uredo Secalis Corda, Oekon. Neuigk. und Verh. 1: 10. 1848.

While long known as of rare occurrence in central Europe, the bunt of rye has apparently not been reported in North America. Recently, in connection with a study of the smuts of New York state, the writer had occasion to examine a specimen from the Underwood herbarium at the New York Botanical Garden, which bears the following data: "Ustilago on Rye, Syracuse, N. Y., June, 1892, L. M. Underwood." This examination revealed the fact that the sori were confined to the grains and the spores were beautifully reticulated, suggesting those of *T. Tritici.* A comparison with European material (Vestergren, Micro. rario selecti *1474*) and with published descriptions suggested that the collection made by Underwood might properly be referred to *Tilletia Secalis.*

While resembling *T. Tritici,* and by some writers included with it[2] this species differs in certain characters. The sori are very much the shape of the normal rye grain but somewhat shorter and broader. The reticulations are 1.5–2.5 μ high and 3–4 μ wide, while in *T. Tritici* they are described as 1 high by 2–4 μ wide. The spores of *T. Secalis* averages slightly larger than in *T. Tritici.*

The New York collection consists of a single somewhat abnormal head. Some of the lower spikelets have developed long internodes so that the head appears much broader at the base than in the normal form. On account of this abnormal appearance and in order to make sure that no mistake in the identification

[1] Contribution from the Botanical Department of the Purdue University Agricultural Experiment Station.

[2] Cf. Schellenberg, Beiträge Krypt. Schweiz 3^2: 90–94. 1911.

of the host had been made the specimen was submitted to Prof. A. S. Hitchcock and Mrs. Agnes Chase, who reported that the specimen was without doubt cultivated rye. Dr. C. H. Leighty, of the Office of Cereal Investigations, also examined the specimen and reported that there was no evidence that it could represent a rye-wheat hybrid.

On account of the importance of rye as a cereal crop in this country the existence of this old collection is considered worthy of note. While the validity of *T. Secalis* is questioned by some authorities, it seems best for the sake of emphasis to record the collection under the above name.

TILLETIA HOLCI (West.) Rostrup, Bot. Tids. **22**: 256. 1899

Polycystis Holci Westend, Bull. Acad. Belg. II. **11**: 651. 1861.
Tilletia Rauenhoffii Fisch. de Waldh. Aperçu Syst. Ust. 50. 1877.

This very distinct species, long known in Europe, has not been reported for North America. It occurs on species of *Notholcus* and collections have been made by the writer in Oregon an *Notholcus lanatus* as follows:

Elk City, August 20, 1914, *1378*; Yaquina, July 17–20, 1915, *3017*.

The sori are obovoid, 1.5–2 mm. in length and occur in the ovaries nearly concealed by the glumes. The spores are chiefly globoid, 24–26 μ in diameter, occasionally ellipsoid, 24–26 by 26–30 μ, the wall cinnamon-brown, beautifully reticulated (measurements include the colorless reticulations which are 2.5–3 μ high). This smut was very abundant at Yaquina in 1915 and was collected in considerable quantity. All the ovaries in infected heads appear to be smutted.

ENTYLOMA COLLINSIAE Harkness, Bull. Cal. Acad. Sci. **1**: 40. 1884

According to Clinton[3] this species is reported only on *Collinsia bartsiaefolia* from the type locality, Mt. Tamalpais, California. The following collections made by the writer in western Oregon, besides extending the range add two new hosts.

[3] N. Am. Flora 7: 63. 1906.

On *Collinsia grandiflora* Dougl. Mary's Peak, Benton Co., May 21, 1915, *3413*.

On *Collinsia tenella* (Pursh) Piper. Corvallis, Benton Co., April 8, 1914, *1696*, April 11, 1915, *3411*.

Urocystis Trillii sp. nov.

Sori hypophyllous on yellowish spots, subcostal, or caulicolous, round or oval, 0.5–1.5 mm. across, scattered or more commonly gregarious in more or less circular groups 5–10 mm. across, caulicolous sori often elongated, reaching 1 cm. in length, opening tardily and exposing the purple-black spore mass; ruptured epidermis cinereous and conspicuous; spore balls chestnut-brown, globoid, 24–50 μ, or ellipsoid, 30–40 by 50–70 μ, occasionally smaller; sterile cells subgloboid or polygonal, 5–9 μ, wall golden-brown, 1–1.5 μ thick, collapsing with age; spores subgloboid, ovoid or polyhedral, few to many in a ball, 3–20, rarely only one or two, mostly 10–15 μ, wall 2–3 μ thick, chestnut-brown.

On *Trillium chloropetalum* (Torr.) Howell. N. W. Corvallis, Benton Co., Oregon, April 13, 1912, F. D. Bailey, *1066*, May 19, 1912, F. D. Bailey, *1094*, April 7, 1914, *1811*, April 11, 1915, *3420*, May 1, 1915, *3408*, May 6, 1919, *3437* (type); Mary's River, Benton Co., June, 1911, *1097*.

Unless otherwise noted the collections were made by the writer.

This smut is very characteristic and conspicuous. The sori on the leaves are usually grouped together, the individual sori roundish or oval, usually 0.5–1.5 mm. across. On the veins and stems the sori are often confluent and quite large, reaching 1 cm. or more in length. With one exception the collections were made in one spot in low, rich land along a stream. The smut appeared in abundance each year.

UROCYSTIS ORNITHOGALI Koern.; Fisch. de Waldh. Aperçu Syst. Ust. 41. 1877

This species, occurring in Europe on *Ornithogalum*, has been more commonly referred to *U. Colchici* (Schlect.) Rab., but is considered distinct by Schellenberg[4] in his recent treatment of the smuts of Switzerland. The writer is inclined to agree with this

[4] Beiträge Krypt. Schweiz 3^2: 139. 1911.

view and to assign to *U. Ornithogali* collections on *Quamasia* made in Indiana and Oregon as follows:

Quamasia hyacinthina (Raf.) Britton. Lafayette, Tippecanoe Co., Indiana, May 30, 1907, F. Vasku; May 22, 1916, H. S. Jackson; May, 1917, G. N. Hoffer.

Quamasia quamash (Pursh) Coville. N. W. of Corvallis, Benton Co., Oregon, April 7, 1914, H. S. Jackson, *1969*; May 1, 1915, H. S. Jackson, *3409*.

According to this treatment, the smut on Liliaceous hosts belonging to the tribe Scilleae, including besides the American *Quamasia*, species of *Muscaria, Ornithogalum* and *Scilla* in Europe, would be assigned to *U. Ornithogali*, while *U. Colchici* would include the European form on *Colchicum autumnale*. The writer is not able to express an opinion as to whether the form on Convallariaceae in Europe and America is properly assigned to either of the above species, as sufficient material has not been available for study. Clinton[5] has assigned specimens on *Salamonia* and *Vagnera*, collected in Iowa and Montana, somewhat doubtfully to *U. Colchici*.

U. Ornithogali differs from *U. Colchici* chiefly in the widely different character of the sorus, the size of the spores, and the character and wall color of the surrounding layer of sterile cells. In the former the sori are elliptical, commonly half as broad as long, the spore balls consist usually of one, rarely two spores, which are 18–22 μ in diameter, and the sterile cells form a firmly united unbroken spore covering, the walls of which are cinnamon-brown. In the latter the sori are linear, often ten or more times as long as broad; the spore balls consist of one to two, rarely three spores, which are 14–20 μ in diameter; the sterile cells with light cinnamon-brown walls form a loose often interrupted layer over the spores.

TUBERCINA TRIENTALIS Berk. & Br. Ann. Mag. Nat. Hist. II. **5**: 464. 1850

In North America this species has apparently been reported only from Alaska on *Trientalis arctica*. Three collections have

[5] Bost. Soc. Nat. Hist. Proc. **31**: 452. 1904; N. Am. Flora **7**: 57. 1906.

been made in Benton County, western Oregon, and are represented in the herbarium of the Oregon Agricultural College and that of the writer. All were made on *Trientalis latifolia* as follows: Philomath, April 20, 1912, H. S. Jackson and F. D. Bailey, *1093*; Corvallis, May 19, 1912, F. D. Bailey, *1098*, April 8, 1914, H. S. Jackson and F. D. Bailey, *1695*.

All three collections are ample and show both the conidial and chlamadospore stages. In our specimens the chlamadospore sori are confined to the stems and petioles. The conidial stage usually covers the entire upper surface of the leaf, though occasionally occurring in isolated pustular patches.

USTILAGINACEAE

Cintractia minor (Clinton) comb. nov.

Cintractia axicola minor Clinton, Jour. Myc. **8**: 143. 1902.

The writer is of the opinion that this *Cintractia* is deserving of specific rank. It not only shows constant morphological differences from *Cintractia axicola* (Berk.) Cornu but occurs on a different host genus. Seven collections have been examined and the characters found to be constant. All are on *Cyperus Grayii* Torr. The first collections of which we have any knowledge were made at Atlantic City, New Jersey, Sept., 1884, by E. W. D. Holway, and Sept. 8, 1884, by J. C. Arthur. A collection was made by J. J. Davis at Sandy Hook, N. J., Aug., 1887, and by J. L. Zabriskie, Aug. 15, 1887. J. B. Halsted also found it at Sandy Hook, N. J., Aug. 15, 1889, and his collection was distributed in Ellis & Everhart's North American Fungi as no. *2423* (type of *C. axicola minor* Clinton). J. C. Arthur made a collection at Rockaway Beach, Long Island, Aug. 14, 1887. The writer also collected this species Oct. 4, 1907, at Selbyville, Delaware.

In this connection it is worthy of note that a typographical error has been made in the citation of Sandy Hook, New York, as the type locality. The printed label on the specimens distributed in Ellis & Everhart's North American Fungi *2423* does give Sandy Hook, " New York," as the place of collection. This is, however, obviously an error for New Jersey as is shown by

the data on the original specimen in the Ellis collection at the New York Botanical Garden, which was evidently communicated to Mr. Ellis by Dr. Halsted. The distribution by states as now known to the writer is New York, New Jersey and Delaware.

This species under discussion is easily separated from *Cintractia axicola* by the smaller spores, which measure 10–13 μ, while in *C. axicola* the spores are 12–18 μ. The effect upon the host is similar.

SOROSPORIUM SAPONARIAE Rud. Linnea **4**: 116. 1829

This is the type species of the genus and has been reported from North America, so far as can be learned, only from Utah, on *Stellaria Curtisii* Rydb. and *Silene Menziesii* Hooker, by Garrett,[6] and from New York on *Cerastium arvense* by Peck.[7] The writer has recently examined specimens as follows, adding three new hosts for North America and extending the distribution to include Nevada and Colorado:

On *Cerastium oreophilum* Greene, Golden, Colorado, May, 1914, E. Bethel.

On *Silene Watsoni* Robinson, near Mt. Rose, Nevada, July 21, 1918, N. F. Petersen, *362*.

On *Stellaria Jamesiana* Torr., Golden, Colorado, June 12, 1905, E. Bethel.

Thecaphora Iresine (Elliott) comb. nov.

Tolyposporium Iresine J. A. Elliott, Mycologia **11**: 88. 1919.

In the fall of 1918 Mr. C. C. Deam, of Bluffton, Indiana, sent to the writer, among other parasitic fungi, an interesting smut on *Iresine paniculata* (L.) Kuntze, which he had collected Sept. 21, 1918, in a dried up wooded slough about one half mile south of Half Moon Pond, which is about ten miles southwest of Mount Vernon in Posey County, Indiana. (Deam, no. 26651.)

This was at once recognized as a species of *Thecaphora* and an examination of the literature revealed that only one species of this genus was known in North America on Amaranthaceae,

[6] Garrett, A. O., Mycologia **2**: 226. 1910; **6**: 240. 1914.

[7] Peck, C. H., Bull. N. Y. State Museum **131**: 27. 1909.

namely, *Thecaphora Thornberi* Griffiths.[8] The specimen on Iresine, while agreeing in general with the description of that species, seemed to differ in important characters. A definite decision with reference to the relation of the two forms was therefore reserved till the type of *T. Thornberi* could be examined. Through the kindness of Dr. Griffiths two collection of his species, one of which was the type, were furnished for study.

The *Iresine* smut is evidently very closely related to *T. Thornberi* but differs in several important respects. The sori, while involving the ovaries, are not usually confined to them, as described for *T. Thornberi,* but are indefinite, involving the ovaries and the perianth of single flowers or groups of flowers and also occasionally the rachis. The spore balls are much smaller in the species under discussion, measuring 40–75 μ in globoid balls, reaching 90 μ in occasional ellipsoid balls, while in *T. Thornberi* the globoid balls are 80–115 μ in diameter, reaching 145 μ in the ellipsoid ones. The spores are somewhat larger and the markings more prominent than in *T. Tornberi.*

The followng description was drawn up as a result of this study:

Sori localized in the inflorescence, involving the ovaries and perianth of one or a group of flowers, often involving the rachis, forming irregular galls 0.3–3.5 cm. long, enclosed by a firm grayish-green membrane, which ruptures irregularly, exposing the reddish-brown spore mass; spore balls solid, subsphaeroid, 40–75 μ, or ellipsoid, 50–70 by 60–90 μ, light chestnut-brown, composed of many, 15–70, spores; spores variable in shape, irregularly polyhedral, prismatic or oblong, 12–20 by 25–32 μ; inner wall thin, 1–1.5 μ, colorless or pale cinnamon-brown, smooth; exposed wall 2–4 μ thick, darker in color with prominent verrucose-rugose markings.

After this study was finished, but before the present paper was completed, the species was described as *Tolyposporium Iresine* from the same collection (Deam, 26651) by Dr. J. A. Elliott (l. c.). The species, however, obviously belongs to *Thecaphora* rather than *Tolyposporium* and this transfer is therefore made above. The author evidently failed to take into account the

[8] Bull. Torrey Club 31: 88. 1904.

existence of the very closely related *T. Thornberi*. Our description is somewhat at variance with the one previously published. The sori in our part of the type collection, which is fairly ample, are not confined to the ovaries and the spore balls do not appear to be hollow, nor do we find any evidence that the cells of the spore balls adhere "by folds of their outer . . . membrane."

TOLYPOSPORIUM JUNCI (Schroet.) Woron. Abh. Senck. Nat. Ges. **12**: 577. 1881.

Sorosporium Junci Schroet. Abh. Schl. Ges. Vat. Cult. **1869–1872**: 6. 1872.

This species is the type of the genus and occurs rather rarely in various parts of Europe, but has evidently not been reported from North America. The writer has made two collections in Oregon, both on *Juncus bufonius* L., one at Corvallis, Benton Co., July, 1910, and the other at Garden City, Multnomah Co., Aug., 1909, *1807*. The fungus is described as attacking the ovaries the stalks and also occurs at the base of the plant. In our specimens the infection occurs most commonly at the nodes, affecting the host somewhat similarly to *Cintractia axicola* on *Fimbristylis*, though often occurring at the base of the stalks. The spore mass is black, composed of spore balls of variable size and shape, 10–50 μ or more and composed of few to many rather small, irregular spores, 7–14 by 10–18 μ. The exposed spore wall is chestnut-brown and minutely verrucose.

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ANOTHER NEW TRUFFLE

W. A. Murrill

In the last number of *Mycologia*, Miss Gilkey described two new American species of truffles, *Tuber canaliculatum* and *T. unicolor*, the latter based on material recently collected in the vicinity of New York City by the use of a dog trained in Europe. After working over this New York material, Miss Gilkey examined and carefully compared with it some specimens collected by Dr. Shear in Maryland twenty years ago, and pronounced them similar but specifically distinct.

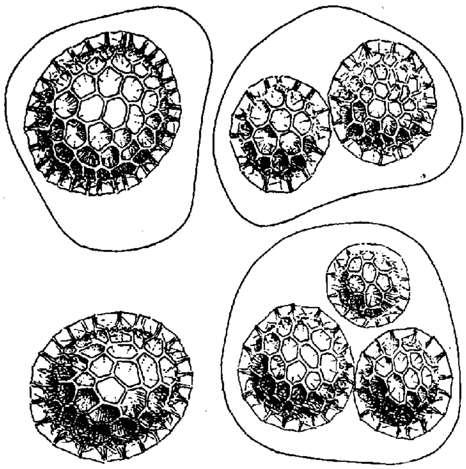

Fig. 1. Asci and spores of *Tuber Shearii*. × 600.

It therefore becomes my duty and privilege (since Dr. Shear seems too diffident) to publish another new truffle from the eastern United States; — and the task is an extremely easy one. Dr. Shear collected the specimens, made the drawing here published, and sent me his correspondence with Dr. Harkness

and Miss Gilkey; while the critical study and comparison was made by Miss Gilkey, whose results are freely incorporated. The description was originally drawn by Dr. H. W. Harkness, of California, in December, 1899, shortly before his death, but his measurements and terms have been somewhat changed.

Tuber Shearii Harkness, sp. nov.

Ascocarp very small, subrotund or slightly elongate; surface smooth, creamy-buff; gleba drab; veins minute; asci many, subglobose, 50–70 μ in diameter, 1–3-spored; spores globose or subglobose, dark-brown, alveolate, minutely reticulate beneath the alveoli, 28–49 μ in diameter; alveoli 9–10 $\times$ 5–6 μ across diameters.

Type collected under *Pinus inops* in Takoma Park, Maryland, October, 1899, *C. L. Shear.* The specimens sent to Dr. Harkness could not be found, but Dr. Shear still had a portion of the original collection and this was sent to Miss Gilkey for examination. Under date of February 14, 1920, she wrote me as follows:

"After having very carefully compared the co-type of *Tuber Shearii,* which Dr. Shear sent me last week, with material of *T. unicolor,* I do not consider the two plants similar. *T. Shearii* has much larger spores with distinctly different sculpturing and color and these differences are constant for all the material studied. Other than spore differences probably occur in these two species, but since all my material of one was dried while the other is in formalin, and since you wished an immediate answer, I have not yet taken time to investigate further, particularly since the constant differences in spores are sufficiently distinctive, in my judgment, to separate the two."

NEW YORK BOTANICAL GARDEN.

NOTES AND BRIEF ARTICLES

[*Unsigned notes are by the editor*]

Readers of MYCOLOGIA are invited to contribute to this department personal news items and notes or brief articles of interest to mycologists in general. Manuscript should be submitted before the middle of the month preceding the month in which this publication is issued.

Dr. Carl Hartley, formerly pathologist in the Office of Forest Pathology Investigations, Bureau of Plant Industry, has resigned to take a position in the Institute for Plant Diseases at Buitenzorg, Java.

Dr. W. H. Rankin, for five years assistant professor of plant pathology in the New York State College of Agriculture at Cornell University, has been appointed officer-in-charge, Field Laboratory of Plant Pathology, St. Catharines, Ontario, in the Canadian Department of Agriculture.

Mr. Emery D. Eddy, who has been engaged during the past year in the investigation of diseases of market vegetables for the Department of Agriculture, recently resigned his position to take up commercial work.

Professor Guy West Wilson has returned to the department of biology in Upper Iowa University, Fayette, Iowa. While at Clemson College in South Carolina, he collected a number of interesting fungi, an account of which will soon appear in MYCOLOGIA.

Oak mildew, according to Poeteren, may be effectively checked for an entire season by a single application of lime-sulphur spray, if used when the mildew begins to develop vigorously.

A new and effective disinfectant for pear blight is said by Reimer to be a 10 per cent. solution of commercial formaldehyde

in water, which should be applied to all tools used and all wounds made in connection with blight work in pear orchards.

Silver leaf of fruit trees, especially injurious to choice varieties of the plum, has become a serious scourge in some parts of England. The only remedy seems to be the speedy and thorough removal of all affected trees or parts of trees, as is done in the case of pear blight.

Fomes lucidus is parasitic on a number of trees in Barbados, according to Nowell, including lime trees, *Pithecolobium saman, P. unguis-cati, Caesalpinia coriaria,* and species of *Acacia,* the trunks of which are usually attacked at the center.

Whitten has found that winter injury to the buds of fruit trees in Missouri, where they are liable to develop too early and be killed by the frost, may frequently be prevented by spraying with whitewash, which reflects the heat of the sun and thus retards development. Anything that will maintain late growth in the fall will also tend to delay the flowering period the following spring.

Snapdragon rust, according to Peltier, has been in California since 1879 and in Illinois since 1913. It can not be controlled by Bordeaux or similar fungicides, but the conditions under which snapdragon plants are grown must be carefully watched. Watering the plants from below checks the ready dissemination and germination of the spores, while propagation from seed would probably prevent the disease entirely, since the rust spores are not carried on the seed of the snapdragon.

Patouillard, the famous French mycologist, has observed *Ustulina vulgaris* to be the cause of a fatal disease of the linden. The fungus attacks the trunk at the surface of the ground, spreads over it for a foot or more, penetrates the sapwood and heartwood, and kills the tree apparently by parasitic action.

A disease of the walnut tree in France is said by Paravicini to be due to the attacks of *Favolus europaeus,* one of the common polypores ordinarily considered non-parasitic. According to this investigator, the fungus enters the trunk through wounds and is frequently found associated with other fungi.

Professor E. T. Bartholomew, of the Department of Botany of the University of Wisconsin, has accepted a research professorship in the Graduate School of Tropical Agriculture at Riverside, California, in connection with the University of California. His special work will be the investigation of the diseases of lemons and other citrus fruits.

Professor H. M. Fitzpatrick, of Cornell University, has made arrangements to teach in the summer school of the University of Michigan. He has just completed a monograph of the Coryneliaceae, which will appear in part in the July number of *Mycologia.*

Tyrosin in the fungi is discussed by C. W. Dodge in the *Annals of the Missouri Botanical Garden* (6: 71–92. 1919). He investigated the chemistry of the tyrosinase reaction in certain species that turn blue or black on exposure to the air, and found: "(1) that the tyrosinase reaction is not a deamination, although it is possible that deaminases may exist in the same organism with tyrosinase; (2) that the tyrosin molecule is synthesized into a larger, more complex molecule, in which part of the carboxyl groups is either split off as carbon dioxide, or more probably bound in the molecule so that it will not react with alkali."

"Études sur la biologie et la culture des champignons superieurs" is the title of a paper of 116 pages and many illustrations published by Monsieur G. Boyer at Bordeaux in 1918. Cultures from spores were usually unsatisfactory, so he was forced to use portions of the hymenophore. The best medium seemed to be

a decoction from carrots solidified with gelose. Mycelium obtained from spores of *Morchella* was vigorous, but no fruit-bodies were formed, probably owing to the necessity of a mycorhizal host previous to ascocarp formation. He found that saprophytic fungi grew readily on culture media, but this was not true of mycorhizal forms associated with certain trees in a symbiotic relationship.

An illustrated article by Hartley and Hahn on the diseases of the quaking aspen, probably the most widely distributed tree of our American forests, appeared in *Phytopathology* for March, 1920. After a discussion of fungi attacking the leaves, twigs, and trunk, the authors conclude with the following summary: "Observations have shown quaking aspen in certain areas to be unusually subject to disease; trunk cankers of unknown origin seem to be especially important factors in shortening the life of the trees. *Fomes igniarius* is also an important factor in causing premature death of aspen in the Pike's Peak region. Interesting but less important diseases are (1) a twig blight suggesting in appearance the fire blight of pear; (2) a leaf disease due to *Sclerotium bifrons*, E. & E., distributed from the Rocky Mountains to New England and also attacking Lombardy poplar but not *Populus grandidentata;* and (3) a rapidly spreading bark trouble which kills cuttings."

A widespread leaf-spot disease of the German Iris caused by *Heterosporium gracile*, or *Didymellina Iridis*, is discussed at length by W. B. Tisdale in *Phytopathology* for March, 1920. This disease seems to occur wherever the susceptible, broad-leaved species of Iris are grown, having been reported from Wisconsin, New York, California, England, and elsewhere. The fungus overwinters in the mycelial stage in the dead leaves. Perithecia develop early in the spring, but do not always produce asci, apparently on account of the weather conditions. Sterile perithecia bear conidia on the apex. An abundant crop of conidia, always present early in the spring, serves as the chief source

of primary infection. The only mode of penetration found during the experimental work at Madison was through the stomata. The removal of dead infected leaves before the young leaves appear in the spring promises to be a successful means of control.

"Short Cycle Uromyces of North America" is the title of an illustrated paper by G. R. Bisby in the *Botanical Gazette* for March, 1920. The characters, relationships, life history, cytology, hosts, taxonomy, and bibilography of this group of rusts are discussed in a rather comprehensive way. No new species are described. The following conclusions are drawn: "Eleven species of *Uromyces* possessing only telia and pycnia, or telia alone, are now considered to be present in North America. These are found especially in the higher and warmer portions of the continent, and occur upon seven widely separated host families. While these rusts form a group agreeing as to life cycle and as to the 1-celled character of the teliospores, it is not considered that phylogenetic interrelationship is thereby shown, morphological evidence indicating rather that the relationship of a species of these rusts is found in other rusts (of various life cycles and with 1- or 2-celled teliospores) upon the same or related hosts. Indeed, as indicated under *Uromyces heterodermus,* a group of hosts may bear a number of rusts of various life cycles, belonging to *Puccinia* and *Uromyces,* widely distributed geographically, yet all showing a certain unanimity of morphological characters, especially in the telial stage."

"Dothidiaceous and Other Porto Rican Fungi," by F. L. Stevens, with 2 plates and 3 figures in the text, appeared in the *Botanical Gazette* for March, 1920. One new genus, *Halstedia,* and the following fifteen new species were described: *Uleodothis Pteridis, Dothidella portoricensis, D. flava, Catacauma Ocoteae, C. palmicola, C. Gouaniae, Phaedothopsis Eupatorii, Halstedia portoricensis, Dimerina monenses, Gloniella rubra, Guignardia Justiciae, G. Tetrazygiae, G. Nectandrae, Zignoella algaphila,* and *Phyllosticta bonduc.*

At a recent meeting of the Botanical Society of America at St. Louis, a request was presented to the Council of the Society for the establishment of a Mycological Section. The form of this request was as follows:

"We, the undersigned members of the Botanical Society, consider it highly desirable and necessary, for the better promotion of mycological research and the more efficient presentation of papers on fungi, that a separate section be established and a segregated program be given at our annual meetings.

"Therefore, we ask the Council of the Botanical Society to institute at this time a new section, to be called the Mycological Section, to include papers on fungi in all phases, in so far as these do not conflict with the interests of the American Phytopathological Society."

The Council granted the request and, at the instance of Secretary Schramm, a meeting of the signers of the memorandum was called and Dr. C. H. Kauffman was elected chairman of the new Section.

PIER ANDREA SACCARDO

Professor Saccardo, so well known to mycologists, died at Padua, Italy, February 12, 1920. Born at Treviso, April 23, 1845, he was assistant in the Botanical Institute of the University of Padua, 1866–72; professor of natural history in the Technical Institute at Padua, 1869–79; became professor of botany and director of the botanic garden of the University of Padua in 1880; and retired in later years as professor *emeritus*. For a list of his publications, see Lindau & Sydow's "Thesaurus."

The writer has visited him at Padua and also at Selva, where one of his summer homes was located, and always found him busy with plans regarding his "Sylloge." Shortly before his death, he sent in a paper for publication in *Mycologia,* which will appear in the next number. The passing of Saccardo adds another distinguished name to the heavy toll of mycologists taken during the past few years.

W. A. MURRILL

A MYCOLOGIST IN THE MAKING

An excellent collection of Ohio fungi was recently sent to me for determination by Mr. W. R. Lowater, a beginner in this field, and the letter accompanying it is so good that I will quote a few paragraphs from it to encourage other beginners:

"For a person like myself, without even a common school education, to attempt unaided the collection of the fungous flora of a certain locality, must seem to a person like yourself as rank impertinence, or at best unwarranted presumption. But I beg of you to suspend judgment. This is not the first great task I have undertaken, nor by any means the greatest. Against all handicaps, I have pitted my usual persistence and self-reliance, supplemented by a love for the chosen task; and, if the progress I have made in the last two years is any criterion of future advancement, you will have little cause ever to feel ashamed of your protégé,—if I may so call myself.

"Furthermore, the university student has the advantages of botanical libraries, lectures, technical instruction, herbaria, and scientific apparatus, while I have had none of these, and have had to grope my way. Only recently have I been placed in a position to buy literature on the subject, and I am slowly acquiring such apparatus as my limited means will allow.

"All that I desire is a start. Should you feel constrained to say, 'Don't! The task is too great for you—you are not qualified for it,' I will only the more solicit your patience. Should the bungling descriptions I have prepared grate on your 'scientific' nerves, I hope that a consideration of the conditions under which I have worked will prevent you from treating the entire matter with levity."

Everyone must bow, sooner or later, to determination and devotion; and mycology needs earnest workers in all sections of the country. Specimens well collected and preserved are always valuable, whether the collector has studied Latin or not.

W. A. MURRILL

KAUFFMAN'S AGARICACEAE

"The Agaricaceae of Michigan," by Dr. C. H. Kauffman, which appeared in 1919, is a stupendous piece of work splendidly done. No one who has not tried something of the kind can realize what such an undertaking means. The detailed descriptions of fresh specimens as they accumulated during the years; their determination from scattered types and inadequate literature; the photographs and drawings; the careful microscopic work; the serious questions relative to poisonous species;—all these and more have been the task of Dr. Kauffman.

The volume of text contains 924 pages, most of which are required for the descriptions of the 884 species listed for Michigan. The introductory remarks include discussions regarding the structure, habit of growth, distribution, collection, and classification of the gill-fungi; while the volume closes with a glossary and bibliography by the author and a lengthy paper by Dr. O. E. Fischer on mushroom poisoning. The second volume consists of 162 full-size plates illustrating in black and white a total of 185 species, many of which have not been illustrated elsewhere.

The new species published in this work, not to mention the new varieties, are thirty in number, a list of which follows. They are to be credited to Dr. Kauffman unless otherwise indicated:

Russula ochraleucoides, R. subpunctata, R. amygdaloides, Hypholoma peckianum, Psilocybe larga, Cortinarius iodeoides, C. velicopia, C. rubens, C. elegantioides, C. aggregatus, C. sphaerosperma, C. purpureophyllus, C. virentophyllus, C. subpulchrifolius, C. subtabularis, C. mammosus, C. impolitus, C. subrigens, Inocybe lanotodisca, I. glaber, Hebeloma simile, Galera bulbifera, G. cyanopes, Crepidotus stipitatus, Eccilia pirinoides, Amanita chrysoblema Atk., *Lepiota fischeri, Pleurotus albolanatus* Pk., *Tricholoma laticeps*, and *Clitocybe praecox*.

W. A. MURRILL

Phytopathology for January, 1920, contains an article on Dr. Farlow, by G. P. Clinton; one on the potato mosaic disease, by H. M. Quanjer; and abstracts of the phytopathological papers presented at the recent meeting in St. Louis.

In reporting on the potato wart survey for 1919, Dr. Lyman states that the disease was found in small amounts in six villages

in western Pennsylvania and in two villages in northern West Virginia, all being in the soft-coal section, except one of the West Virginia localites. Apparently no other extensive area of infestation exists at all comparable to the Hazleton district, but undoubtedly there are other undiscovered isolated points of infestation in regions out of touch with modern agriculturists. These can be brought to light only by further intensive survey.

"Wood-destroying fungi in pulp and paper mill roofs" was the title of a paper presented by Mr. R. J. Blair, which was abstracted as follows: When the roof of a paper mill is built of wood moisture in the air permits the development of wood-destroying fungi in the timber. Rapid rotting takes place and it is often necessary to renew the timber after six or eight years' service. The roofs of eighty of the Canadian paper mills have been examined to find the different types of construction used and the services secured from each. The common faults in every case are that moisture enters the spaces between the planks and reaches their upper side, where it condenses, causing a moist condition of the planks during prolonged periods and at the same time the wood is of a non-durable species. There is no evidence that other species of fungi than three of those mentioned last year in connection with the cotton mill roofs, *Lentodium tigrinum, Lenzites trabea,* and *Poria xantha,* cause these losses. The remedy for such timber decay lies in a combination of four factors, which need consideration when the roof is being built. These are the use of wood which resists decay, ventilation which carries away the moisture, liberal dry-air heating, and a heat-insulating layer placed on the upper side of the planks.

Dr. J. C. Arthur reported that there were two destructive rusts ready to invade the United States at the first opportunity. A rust on peanuts has long been prevalent in South America. In Trinidad and the nearby islands of the Antilles it is a great menace to the crop, often covering every leaf on the plants with a heavy powder of urediniospores. No successful method of controlling the rust has yet been found. A rust on potatoes and tomatoes, comparable in its life history and behavior with the hollyhock rust, has recently come to light in Costa Rica and Ecuador. The possibilities for its spread and harmfulness de-

serve serious attention. Neither this rust nor the preceding one has yet been reported from any United States possession.

The biology of *Fomes applanatus* is ably and comprehensively treated by J. H. White in the *Transactions of the Royal Canadian Institute* **12**: 133–174. *pl. 2–7.* 1919. Two of the most important results obtained relate to the discharge of spores and to the parasitic nature of the fungus. These are summarized by the author as follows:

"Spore discharge is enormous and continues for by far the longest period recorded for fungi. It is continuous day and night for about six months—visible from vigorous fruiting bodies as spore clouds. Buller, from a count estimate in the case of *Polyporus squamosus,* a form which also exhibits spore clouds, concluded that at least 1,700,000 spores were discharged from one tube in three days. A similar calculation with *F. applanatus* gave the incomprehensible number of 30,000 million spores liberated in twenty-four hours from a fruiting body with a pore surface of about one square foot. Discharge is not affected by variations in light, humidity of the air, or temperature within very wide limits; frost causes an instant cessation and thereafter there is no further spore fall until a new set of pores is organized.

"*Fomes applanatus* has been proved to be a wound parasite, and in southern Ontario at least one of the commonest and most destructive of this type. The proof rests on three grounds: (*a*) the conventional test applied to other such fungi—the mycelium works upward most readily by the way of the heartwood, causing a characteristic decay and outward into the sapwood, eventually reaching the cambium, and is apparently the cause of the death of the tissues traversed by it; (*b*) a broad brown band is present in the wood of living trees along the advance line of the invading mycelium of this fungus. Within this band there is a copious production of brown wound gum and an excessive multiplication of tyloses. This band steadily moves forward with the advancing hyphae, the tyloses and wound gum being destroyed by the mycelium along its posterior margin as rapidly as they are formed along its anterior edge. The tyloses (and possible the wound gum also) certify to the living condition of the invaded tissues;

their production can be ascribed only to the influence of the fungus, and the invasion of these tissues and their fate demonstrates directly its ability to act as a parasite; (*c*) inoculations with the spores and mycelium of *F. applanatus* into living trees resulted in an extensive browning of the inoculated wood with a multiplication of tyloses—both far in excess of similar phenomena due to traumatic stimulation."

OUDEMANS' WORK ON FUNGI

The first volume of Oudemans' "Enumeratio Systematica Fungorum," with about 1,360 pages of text, appeared in the latter part of 1919. It contains a bibliography of 2,107 titles and a host index of all the cryptogams and the monocotyledons (as far as the orchids) that occur in Europe, either wild or in cultivation, with the fungi that are parasitic upon them. Engler's nomenclature has been followed in the main for the higher plants and Saccardo's for the fungi.

Oudemans died in 1906, having labored twenty-five years or more on this work. Dr. Lotsy succeeded in getting a Society at Haarlem to publish the manuscript, after it was revised and completed up to the year 1910 by de Boer, Paerels, and Vuyck. The first volume may be obtained for fifteen dollars from Martinus Nijhoff, Lange Voorhout 9, The Hague, Holland. The remaining four volumes are expected to appear in a few years.

This first volume is valuable because of its extended bibliography and the numerous citations to the literature of the fungi which it contains. As a host index for the fungi, it includes all European plants, many of which occur in this country, and also all plants grown in conservatories in Europe, among which will be found many species from tropical America.

W. A. MURRILL

ERRORS IN LINDAU'S "THESAURUS" AND SACCARDO'S "SYLLOGE".

Several years ago I sent in some corrections for Lindau and Sydow's Thesaurus litteraturae mycologicae . . .; a few more have come to my attention which I think may possibly be of interest to the readers of MYCOLOGIA.

In Lindau and Sydow's Thesaurus litteraturae mycologicae . . . under J. A. Mougeot (no. 77) occurs the title: Champignons des Vosges (Statist. du Départ. des Vosges, Epinal 1845, 127 p.); the same title is also given under A. Mougeot, by Traverso in his Supplementum alterum to Saccardo's Bibliotheca mycologicae . . . in the Sylloge fungorum, v. 17, p. lxxii. I have not been able to locate this work but I feel reasonably sure that it is wrongly credited to J. A. Mougeot. There seems to have been considerable confusion of the father (Jean Baptiste) and the son (Joseph Antoine or Antoine, as he is more often) given) by bibliographers. A notable example is that of the Royal Society's Catalogue of scientific papers, 1st series, which, however, corrected the mistake in the supplementary volume. There is no mention of any such work by J. A. Mougeot by his biographers; in fact it would not seem that his published mycological work dates so far back. It is most probably a reprint from J. B. Mougeot's Considérations générales sur la végétation spontanée du département des Vosges. This was first published in the Ann. Soc. Emul. Dép. Vosges in 1834 (Lindau no. 73), but according to Kirschleger in his Flore d'Alsace, v. 2, p. lxx–lxxi, included only the phanerogams; in 1845 it was reprinted with the addition of the cryptogams, in Lepage and Charton's Statistique du Département des Vosges (Lindau, no. 73a, the date 1835 must be a typographical error). An examination of a copy of the reprint of the Considérations générales . . . of 1845, discovers no indication that the son (J. A. Mougeot) had any hand in the work. The part dealing with fungi, both general text and the table of species, would cover about 127 p., which is given as the number of pages for the reprint "Champignons des Vosges."

Nos. 78 and 79, credited by Lindau to J. A. Mougeot, should also be transferred to J. B. Mougeot, the father.

I should be glad to get track of a copy of the "Champignons des Vosges," 1845, and would appreciate information in regard to its location.

It is very possible that the following note of correction for Saccardo's "Sylloge fungorum" has already been brought to the

attention of mycologists; on the chance that it may have escaped notice I am appending it.

Saccardo in his "Sylloge fungorum," v. 2, p. 352, cites as synonyms of *Ophiobolus herpotrichus*

Rhaph. herpotriche (Fr.) Fuck. Symb. Myc. p. 125.

Rhaph. lacroixii Mont. Syll. Crypt. n. 895.

In the "Synonymia" (v. 15 of the "Sylloge," p. 320) the species are given as *Rhaphidophora herpotricha* and *R. lacroixii*. In both cases the name used by Fuckel and Montagne is *Rhaphidospora* and not *Rhaphidophora*. This error should also be corrected in the Index to the "Sylloge" (v. 12, p. 663): *Rhaphidophora* Fr. et Mont. should read *Rhaphidospora* Fr. et Mont.

It might also be well to call attention to the fact that the abbreviation "Car. et de Not." which occurs in a number of places, especially under *Ophiobolus* in v. 2 and in v. 15, p. 320, under *Rhaphidophora*, should read "Ces. et de Not."

ALICE C. ATWOOD

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